# Multi-hazard assessments for disaster risk reduction: lessons from the Philippines and applications for non-governmental organisations

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I, Melanie Jane Duncan confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed ___________________________________ Date_____________________

## Abstract

Disaster risk reduction (DRR) should be underpinned by multi-hazard assessments that integrate community and scientific knowledge. Humanitarian and development non-governmental organisations (NGOs) are key implementers of DRR, but there is little guidance for them regarding the requirements of a multi-hazard approach. Using mainly qualitative methods, a conceptual framework for multi-hazards is proposed, which emphasises the interrelations between hazards as well as the need to address more than one hazard. This framework is compared to existing NGO hazard assessment methods at Head Office and in the Philippines (a multi-hazard hotspot), along with a case study of the 2006 Typhoon Reming lahars disaster at Mayon Volcano. Throughout the research, the role of scientific knowledge is explored.

Interviewees assume that their community-based assessments 'toolkits' capture multi-hazards, but these are constrained by preconceptions related to DRR, the confined temporal and spatial scales of analysis and the emphasis on community knowledge. Particularly amongst Head Office NGOs, the need for science and a more anticipatory approach is driven by climate change adaptation rather than DRR. However, the Reming lahars disaster emphasises that DRR strategies must anticipate, prepare for and respond to simultaneous hazards, whilst accounting for how previous hazards might amplify or alleviate the anticipated event. The disaster emphasises the limits of community knowledge but also those of the available science, along with the need for good communication between scientists, NGOs and communities.

The conceptual multi-hazard framework provides NGOs with a multi-hazard 'lens' to their analyses, but the findings emphasise that multi-hazard assessments require more than a toolkit. NGOs need the skills to access, understand and evaluate science and engage with scientists. There are numerous ideological and practical barriers to integrating science, which

are partly addressed by a set of practical guidelines developed alongside the research. Beyond NGOs, the research has important implications for DRR policy.

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## List of Acronyms

| | |
|---|---|
| APSEMO | Albay Public Safety and Emergency Management Office |
| CAFOD | Catholic Agency for Overseas Development |
| CCA | Climate Change Adaptation |
| CCCD | Commission on Climate Change and Development |
| CBO | Community-based organisations |
| DFID | Department for International Development (UK) |
| DRR | Disaster Risk Reduction |
| GIS | Geographical Information Systems |
| GPDRR | Global Platform for Disaster Risk Reduction |
| HFA | Hyogo Framework for Action |
| ICE | Information Education Campaign |
| ICSU | International Council for Science |
| IDNDR | International Decade for Natural Disaster Reduction |
| IIED | International Institute for Environment and Development |
| INGO | International Non-Governmental Organisation |
| IPCC | International Panel on Climate Change |
| ITCZ | Intertropical Convergence Zone |
| JAXA | Japan Aerospace Exploration Agency |
| LGU | Local Government Unit |
| MDG | Millennium Development Goals |
| MGB | Mines and Geosciences Bureau |
| NAMRIA | National Mapping and Resource Information Authority |
| NGO | Non-Governmental Organisation |
| PAGASA | Philippines Atmospheric, Geophysical and Astronomical Services Administration |
| PCVA | Participatory Capacities and Vulnerabilities Assessment |
| PHIVOLCS | Philippine Institute for Volcanology and Seismology |
| PHVCA | Participatory Hazard, Vulnerability and Capacity Assessment |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNDRO | United Nations Disaster Relief Organization |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNISDR | United Nations International Strategy for Disaster Reduction |
| UNOCHA | United Nations Office for the Coordination of Humanitarian Affairs |
| VCA | Vulnerability and Capacity Analysis |
| VEI | Volcanic Explosivity Index |
| WASH | Water and Sanitation Hygiene |
| WCDR | World Conference on Disaster Reduction |

## Glossary

| Term | Definition |
|---|---|
| *Accumulated rainfall* | Here, taken to mean a measure of rainfall from the beginning of the rainfall event to the time of failure. |
| *Avulsion* | Lahar abandonment of a channel to form a new channel. |
| *Barangay* | The lowest geographical administrative unit in the Philippines. Barangays are located in both rural and urban settings. |
| *Beneficiary* | A recipient of aid. |
| *Capacity* | All the resources, assets and strengths people, society or organisations possess to cope with and recover from shocks and stresses (Wisner et al., 2004; Gaillard et al., 2010; UNISDR, 2012). |
| *Climate change adaptation* | Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNFCC, 2014). |
| *Critical rainfall intensity threshold* | In the context of Mayon volcano, the hourly rate of rainfall that must be reached in order to trigger a lahar. |
| *Debris flow (lahar)* | A lahar of high viscosity and shear strength with typical sediment concentrated in excess of 60% by volume and 80% by weight (Lavigne et al., 2000). |
| *Disaster* | Changes and disruption that exceeds the affected society's capacity to cope (Twigg, 2004). |
| *Disaster risk reduction* | The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (UNISDR, 2009c). |
| *Donor* | A government, institution or individual that funds aid. |
| *Epistemology* | The theory of knowledge (implied in some social science texts to mean what is acceptable knowledge; Bryman, 2008) |
| *Exposure* | The presence of people, livelihoods, environment, economic, social or cultural assets in places that could be adversely affected (Mitchell and Harris, 2012). |
| *Hazard* | A potential threat to humans and their welfare (Twigg, 2004). |
| *Hyperconcentrated flow (lahar)* | A lahar that typically has a sediment concentration from 20% to 60% by volume and 40% to 60% by weight and is intermediate between debris flow and streamflow (see Lavigne, et al., 2000). |
| *Interdisciplinary* | Relating to more than one discipline within a single research endeavour. |
| *International NGO* | They seek funding from individuals, governments or foundations to develop programmes in developing countries depending on their particular vision of development, emergency relief, DRR and CCA etc. They can also provide technical assistance, resources, training and work on advocacy and policy (Thompson, 2013). Some are operational within countries, but many operate through local partners. |
| *Lahar* | A general term for a rapidly flowing, gravity-driven mixture of rock debris and water (other than normal streamflow) from a volcano (Smith and Fritz, 1989). |

| | |
|---|---|
| *Local NGO* | Agencies working with one community or several communities in the same area (Thompson, 2013). |
| *Multi-hazards* | For the purpose of this research, the term multi-hazard reflects the potential for more than one hazard to occur in an area and that hazards are interrelated and therefore might trigger secondary hazards, exacerbate the impact of future hazards or might occur simultaneously. |
| *National NGO* | Based in one country, they can range from huge, multi-activity groups to small single-focus organisations. Usually depend on bilateral institutions, international NGOs and foundations for their funds (Thompson, 2012). |
| *Non-governmental organisation (NGOs)* | Traditionally a not-for-profit organisation independent of government that is funded by institutions or individuals for the purposes of implementing and distributing aid. In this context, NGOs are discussed primarily in the context of humanitarian and development NGOs. |
| *Ontology* | A theory of the nature of social entities (Bryman, 2008). |
| *Proneness* | Used in the context of lahar hazard mapping at Mayon, lahar proneness represents which areas are more likely to be affected but does so on a relative, qualitative scale. |
| *Rainfall duration* | The time interval over which rainfall falls. |
| *Rainfall intensity* | The rate of rainfall over a specific duration. |
| *Resilience* | A contested term, broadly defined as how a system, community or individual can handle a disturbance, surprise or change, by withstanding or adapting to shocks or stresses (DFID, 2011; Mitchel and Harris, 2012). |
| *Risk* | The likelihood of a specific hazard occurring and its probable consequences for people and property (Twigg, 2004). |
| *Science* | The systematic study of the structure and behaviour of the physical and natural world through observation and experiment (Soanes and Stevenson, 2009). |
| *Vulnerability* | The extent to which a person, group or socio-economic structure is likely to be affected by a hazard (Twigg, 2004). |

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# Chapter 1: Introduction

The project 'multi-hazard assessments for disaster risk reduction: lessons from the Philippines and applications for non-governmental organisations' has arisen from the formal partnership between University College London (UCL) and the Catholic Agency for Overseas Development (CAFOD). The partnership was established in 2008 for the purposes of integrating scientific knowledge and research on disaster risk reduction (DRR) and climate change adaptation (CCA) into CAFOD's programmatic and policy work. The thesis is the result of a need identified by CAFOD to explore how non-governmental organisations (NGOs) could improve the way they assess multi-hazards.

In countries exposed to multiple hazards, the challenge is in addressing the range of frequent disasters that undermine development and the higher magnitude events that periodically devastate large portions of the country (CCCD, 2009). Hazards can also interact and cause cascading (chains of) hazards and compounding impacts through the coincident occurrence of unrelated hazards (Ashdown, 2011). The increasing vulnerability and exposure of people and infrastructure in multi-hazard developing countries poses challenges for NGOs and the communities they assist. DRR strategies must be underpinned by a thorough analysis of these underlying multi-hazards. Natural and physical sciences are being increasingly recognised by policy-makers as an essential means of assessing and anticipating disaster risk (UKCDS, 2013) and in identifying means of preventing, preparing for and responding to disasters (Southgate et al., 2013). The NGO DRR sector is, therefore, faced with two challenges: how to implement multi-hazard assessments and how to utilise science for this purpose. The doctoral research addresses these challenges in the context of multi-hazards in the Philippines.

## 1.1 Anticipating disasters in a multi-hazardous world

Disasters have long been acknowledged as not naturally occurring events; instead, they are the consequence of the interplay between hazards, the exposure and vulnerability of elements at risk, the capacity to reduce or respond to the disaster and, more recently, the level of resilience in a system (UNISDR, 2006; Mitchell and Harris, 2012; Wisner et al., 2012). In this thesis the focus is on hazards, rather than vulnerability and risk, owing to the emphasis being on interacting hazards and the application of physical and natural science. The thesis also focuses on natural, rather than human-induced, hazards because they are the focus of the international framework for DRR – the Hyogo Framework for Action (HFA; UNISDR, 2005), which is the means by which many governments and NGOs measure their progress on DRR.

Any strategy for DRR needs to be underpinned by a good understanding and anticipation of the likely severity, timing and location of hazards (Rees et al., 2012). In an increasingly interconnected world, distal hazards can create disasters for countries well beyond the origin of the hazard (Ashdown, 2011). For example, the 2010 European ash crisis caused by the eruption of Eyjafjallajökull Volcano in Iceland resulted in the cancellation of flights across Europe (Sammonds et al., 2010). There is also growing recognition that hazards can manifest as combinations of hazards that are 'a factor of magnitude more difficult' to anticipate than single hazards (Ashdown, 2011: 15). The 2011 Mw9 Tōhoku earthquake in Japan resulted in the deaths of 15,703 people and displaced a further 130,927 (USGS, 2012). Whilst the response to this event reflected the good investment in disaster preparedness, the emergency plans, preparations and mitigation strategies were based on an inadequate assessment of the seismic hazard (Cyranoski, 2011). The magnitude of the earthquake and the accompanying tsunami were, therefore, seemingly unprecedented, but it has emerged that the hazard was in fact underestimated (Normile, 2011). In the Philippines, the devastating Typhoon Haiyan (November 2013) occurred only one month after the Ms7.2 earthquake that killed 209 people in Bohol and destroyed 14, 512 homes, rendering many residents homeless and extremely vulnerable to typhoon hazard whilst living in temporary accommodation (Matus, 2013). These recent events emphasise the need for scientists and decision-makers to anticipate combinations of hazards (Ashdown, 2011). These hazard combinations can equate to more than the sum of the independent hazards (Marzocchi et al., 2012a); for example, the 1991 eruption of Mt Pinatubo in the Philippines was accompanied by Typhoon Yunya, which saturated the accumulating tephra with rainfall, the weight of which caused the roofs of homes and businesses to collapse, resulting in most of the 300 deaths directly associated with the eruption (Wolfe, 1992). In spite of being recognised as a threat, the assessment of these interrelations is a notable omission from multi-hazard risk assessments (Kappes et al., 2012), partly because they are perceived to be too challenging (e.g. Tweed and Walker, 2011). Instead, the majority of analyses tend to compare, rank or aggregate independent hazards for the same location (e.g. Thierry et al., 2008). Furthermore, the DRR advocacy for multi-hazard approaches has not typically been accompanied by guidance for decision-makers (including NGOs) on what these entail (e.g. UNISDR, 2005).

## 1.2 Non-governmental organisations and multi-hazard assessments

Humanitarian and development NGOs are key implementers of DRR strategies. It is imperative, therefore, that they have the skills (or access to those who do) to analyse and understand the risks they are trying to address. NGO approaches to DRR comprise policy and advocacy at the national and international scale and community-based DRR interventions at the local scale (Benson et al., 2001). Historically, responding to disasters has primarily been a concern for humanitarian departments, but with international recognition that disasters can undermine or be caused by development (DFID, 2004) NGOs have attempted to integrate DRR activities across their programmes, to varying degrees of success (Benson et al., 2007).

The divide between humanitarian and development sectors and, therefore, response and risk reduction activities is perpetuated by separate funding streams (DIFD, 2004). These funding streams reinforce humanitarian and development trends including DRR, climate change adaptation (CCA) and, more recently, resilience. The recent emphasis on CCA compared with DRR in the NGO sector indicates a need to question whether NGOs are taking an objective, multi-hazard approach to their interventions. Climate change is being perceived as the greatest threat to vulnerable communities without accounting for the numerous threats and exacerbations of hazard and risk (for example environmental degradation) occurring at the local level (Walker et al., 2014). However efforts to synthesise DRR and CCA reinforce the need for a multi-hazard, integrated approach to risk reduction (Turnbull et al., 2013).

Whilst the policy surrounding DRR, CCA and resilience tends to emphasise a multi-hazard approach (e.g. DFID, 2012), history demonstrates that NGOs have not always successfully ensured that their programmes account for the entire range of hazards that might affect a community or region within which they work. The seismic hazard that caused the January 2010 earthquake in Haiti was overlooked because the emphasis amongst humanitarian and development organisations working in Haiti was on hurricane preparedness due to a succession of tropical storms and hurricanes that had affected the country in recent years (see Nicolas et al., 2009). This situation arose despite the earthquake risk having been identified by seismologists (see Hayes et al., 2010) and publically stated by a prominent local geologist as far back as 2008 (Guha-Sapir et al., 2011). This example highlights that there is a need for better communication between scientists and decision-makers.

The need for humanitarian decision-makers to better anticipate disasters has prompted policy makers to advocate for the better utilisation of natural and physical science in DRR (e.g. Ashdown, 2011). Rather than repeat the positivist and criticised International Decade for Natural Disaster Reduction (IDNDR), the recent guidance emphasises that science must be integrated with community and indigenous knowledge of disaster risk (Southgate et al., 2013). NGOs typically implement risk assessments with local (rural) communities through participatory methods of assessing hazard, vulnerability and capacity that rely upon community knowledge (e.g. IFRC/RC, 2007). But, despite being key actors in international and local efforts to reduce disaster risk, NGOs are notably omitted or underemphasised in some of the recent advocacy for decision-makers to better engage with science for DRR (e.g. Southgate et al., 2013).

There are a number of examples of the positive contributions science has made to DRR (Southgate et al., 2013) and the potential role of partnerships between NGOs and academia for enhancing humanitarian goals is growing in recognition (Green, 2013). However, it is apparent that the uptake and integration of science within NGOs for the purpose of DRR is still largely lacking. This is in spite of the fact that addressing multi-hazard risk requires a range of expertise (Ritchey, 2006). Whether this is because science is largely inaccessible to or simply not appreciated by NGOs is explored in the EngD research.

## 1.3 Aims, objectives and research approach

To date, there has been a lack of appraisal as to whether NGOs adopt a multi-hazard approach in their assessments of disaster risk. There is also a need to determine whether science is widely utilised by NGOs for the purpose of these assessments. The principal research question is, therefore:

> *To what extent do and can NGOs assess multi-hazards and do they incorporate science for this purpose?*

In order to fully address the research question, it is first necessary to determine what the term multi-hazard refers to. The data collection and analysis is then divided into two parts. The first part considers current approaches to NGO hazard assessment, whilst the second part examines the reality of multi-hazards through a case study involving both NGOs and scientists. Pursuing the research in this sequence is crucial since it ensures the research is understood within the context of NGO applications throughout. It also illustrates a progression of the research, from the more general, sector wide consideration of multi-hazards to the specific understanding of a case.

Given the above approach, accompanying the research question are three key research objectives:

1. to identify a conceptual framework for multi-hazards, especially their interrelations, and what is required by their assessment;
2. to determine current methods adopted by NGOs for the purposes of assessing hazards, whether these incorporate a multi-hazard and scientific approach and what factors constrain or enable the implementation of multi-hazard assessments by NGOs;
3. to examine the reality of multi-hazards and their assessment within a case study to support or challenge the findings from the first two objectives.

The EngD research is exploratory, with the findings from earlier objectives being used to inform and refine subsequent research. Given its scope, the research adopts an interdisciplinary and partnership-based model of research In order to address the aim and objectives. The critical analysis of multiple hazards and their interrelations is achieved through the analysis of a case study of multi-hazards in the Philippines. The reason for selecting the Philippines is because it offers a truly multi-hazard environment and, at the beginning of this research, CAFOD and its partners had already started to implement a DRR project there. The model of research and the Philippines are introduced in the following sections.

### 1.3.1 An academic-NGO partnership: the ambition of applied research

Currently, there are two factors driving the increased interest in academic-NGO collaborations. Firstly, funders are demanding that NGOs improve their evidence and results and secondly, academics in the UK are under pressure to demonstrate impact from their work in order to secure future research funding (Green, 2013). A frequent complaint amongst NGOs is that the demands of their work, together with limited staffing and financial resources, negate the time available for research (Roper, 2002). Academics can provide perspective and analytical capacities that are often unavailable in-house (Roper, 2002), although Chapter 9 argues whether this lack of in-house capacity is something that NGOs need to address. For academics, working with NGOs enables the application of research and expertise of tangible benefit to the NGO (Mercer, 2006), whilst simultaneously making a contribution to larger intellectual projects by testing ideas and theories (Roper, 2002).

The UCL-CAFOD partnership creates an opportunity to academically evaluate the extent to which NGOs can implement multi-hazard assessments, as well as identify the factors that limit the implementation of these assessments and the opportunities for improvement from other fields, for example hazard science. At the same time, the partnership provides insight into the NGO sector and the researcher has the benefit of academic and practitioner advice, guidance and expertise.

There are practical and ethical challenges to working in partnership with a group that represents partners, subjects and users of the research (Mercer, 2006; Duncan et al., 2014). Avoiding the pitfalls of NGO-academic partnerships necessitates clear goals of the collaboration, regular communication between project members and a balance between developing theory and solving problems (Roper, 2002; ELRHA, 2012, see case study 3: 45). Chapter 9 contains a reflection on the experience of a partnership based research project with suggestions for the implementation of future collaborative research projects.

### 1.3.2 Interdisciplinary research

There is increasing recognition amongst academics and DRR specialists that no single discipline is suitably equipped to fully understand and develop risk reduction initiatives (Ritchey, 2006). In order to understand and evaluate the concept of multi-hazards and their assessment, it is necessary to adopt an interdisciplinary approach (Tweed and Walker, 2011).

There are major benefits to an interdisciplinary approach: it allows for exploration of the wider context of a research topic and creates opportunities for identifying approaches and strategies from other disciplines. This is particularly helpful in the case of this research where there is an absence of previous research in this field. At the same time, it is necessary to balance this breadth of analysis against what is achievable within a project time-frame. The reader should therefore be aware that in order to address the scope of the project, some topics have received less attention than others, which represents the reality of interdisciplinary research.

Anecdotal evidence suggests that projects that contain an interdisciplinary component end up being framed primarily as either a physical or social science project, especially with regard to methods (Donovan et al., 2011). Methodologically, the EngD project adopts a mainly qualitative approach in order to access the perspectives and experiences of NGOs. However, the project also necessitates an understanding of natural science and quantitative analysis in order to evaluate quantitative methods for assessing multi-hazards. The research strategy is further discussed in Chapter 3.

### 1.3.3 The Philippines as an appropriate case study

The Philippines is widely recognised as one of the most disaster prone countries in the world (GFDRR, 2010; Figure 1.1). The country is exposed to frequent natural hazards (typhoons, floods, landslides, droughts, volcanic eruptions, earthquakes and tsunamis) and interspersed with high impact disasters (e.g. Typhoon Haiyan in 2013). Combined with the vulnerability of a significant proportion of the population, which is closely linked to high levels of poverty and environmental degradation (Benson, 2009), the Philippines is classed as a disaster hotspot. As of 2010, the Philippines had a population of 92.34 million (National Statistics Office, 2014). The World Bank classes the Philippines as a lower-middle-income country, with 25.2% of the population living below the national poverty line (World Bank, 2014).

The tectonic and meteorological setting of the Philippines make it highly susceptible to multiple and interrelated hazards. The archipelago is the consequence of the meeting of three plate margins and is comprised of several volcanic arcs (Yumul Jr et al., 2012). There are four climate types, which each reflect the different patterns of rainfall over the year. In the main, however, most areas are exposed to high levels of rainfall during parts (if not most) of the year (Yumul Jr et al., 2012). The pattern of rainfall is dictated by the incidence of typhoons (on average seven to eight make landfall each year), the north-east and south-west monsoons, the seasonal movement of the Intertropical Convergence Zone (ITCZ) and the El Niño Southern Oscillation, which brings increased rain in La Niña years (Bankoff, 2003; Yumul Jr et al., 2008).

Given the topography, frequent incidence of heavy rainfall and periodic earthquakes, the Philippines is frequently affected by mass movements. These hazards can manifest as primary hazards or as the consequence of another hazard (e.g. earthquake or typhoon) and can also, themselves, trigger subsequent hazards, such as damning lakes that subsequently flood (Yumul Jr et al., 2012).

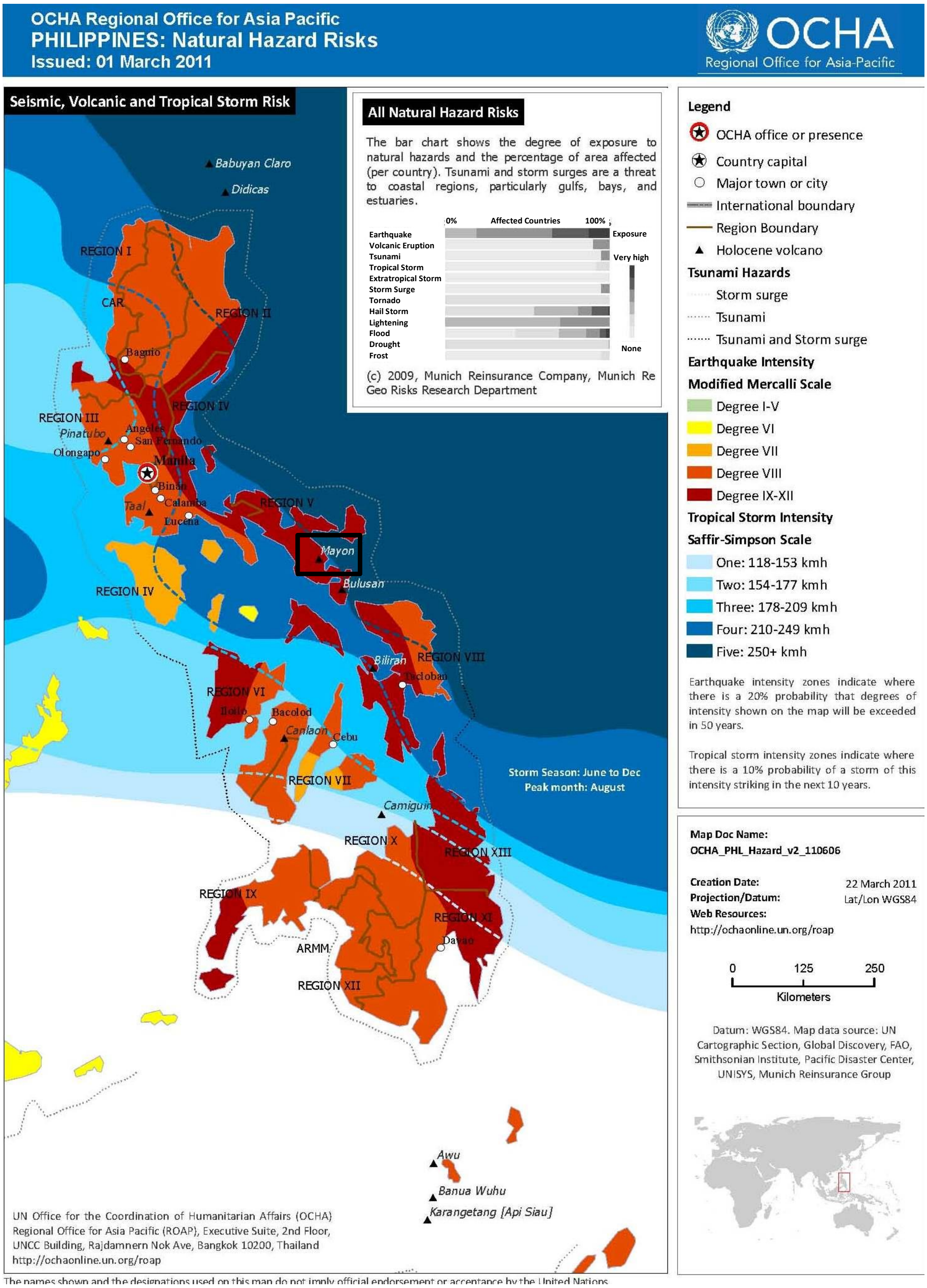


Figure 1.1 Seismic, volcanic and tropical storm risk in the Philippines. The black box indicates the location of the case study: Albay. Source: OCHA (2011).

Home to 22 volcanoes that have erupted within the last 600 years, volcanic eruptions also readily manifest as multi-hazard events that include lava flows, earthquakes, pyroclastic flows, lahars, lightening and ballistics (PHIVOLCS, 2008). Thus focusing the multi-hazard case study analysis in a location where mass movement hazards occur in volcanic systems is an appropriate means of exploring multi-hazards in general. The chosen site is the province of Albay, within which sits Mayon volcano (Figure 1.1). The case analysed is the 2006 typhoon triggered lahars at Mayon and is introduced in Chapter 6.

## 1.4 Thesis outline

The outline of the thesis is as follows: chapter 2 presents a review of the literature, including an analysis of NGOs, the definition of key terminology, the history of DRR and the concept of multi-hazards and their assessment. Within this chapter a working conceptual framework for multi-hazards is proposed. Chapter 3 provides a justification for the qualitative and mixed methods approach to this research, along with details of the methods adopted, their implementation and the means of analysing qualitative data. The remainder of the thesis reflects the division of the research into the two, complementary, parts: (1) ascertaining how NGOs assess hazards and whether they adopt a multi-hazard approach and (2) analysing the multi-hazard characteristics of the case study of the 2006 typhoon triggered lahars at Mayon Volcano, in order to understand the reality of multi-hazards and their assessment. Chapters 4 and 5 present the analysis and findings of the first part of the research, which comprises two studies of NGO community-based hazard assessments: one from the perspective of those from Head Office NGOs in the UK and the other from programme staff and local agencies in the Philippines. Chapters 6, 7 and 8 address the second part of the research. Chapter 6 introduces the rationale for and the geographical context of the case study, as well as providing a reflection on the field work and information used to analyse the case. Chapter 7 provides a narrative of the case study, alongside an analysis of key aspects of the disaster related to the conceptual framework for multi-hazards derived from the literature review (Chapter 2). Chapter 8 presents the current scientific means of anticipating lahar hazard at Mayon volcano, reflecting on their incorporation of a multi-hazard approach and NGOs' means of accessing science and associated expertise. The thesis concludes with Chapter 9, which comprises a synthesis of the findings from both parts of the EngD research and the wider implications of these for DRR, multi-hazard analysis and NGO applications.

# Chapter 2: NGOs, disaster risk reduction and multi-hazard assessments

The chapter begins with an introduction to NGOs, followed by the background to DRR within the humanitarian and development sector, the transition from disaster management to DRR and the overlaps between DRR and climate change adaptation (CCA). The purpose of reviewing this literature is in order to emphasise the context within which multi-hazards are being perceived by humanitarian and development NGOs, their donors and the frameworks they adhere to. Section 2.2 explores the concept of multi-hazard and approaches to their assessment, whilst introducing the roles of natural science and community knowledge in hazard assessment and NGO approaches to hazard assessment. The chapter concludes with a summary of the main findings of the literature review and proposed next steps.

## 2.1 Introduction to non-governmental organisations

There is no generally accepted definition of what is an NGO, owing to the fact that these organisations represent the outcome of the interaction between ideological trends, donor policies and agendas and national historical and cultural conditions (Tvedt, 1998). NGOs also vary in size (international, national and local), values and scope. Hilhorst (2003) argues that scholars of NGOs should move their attention from organisational features, structures and reports to the social actors in and around the organisation. This view emphasises why it is important to speak with individuals within agencies in order to understand their approaches to multi-hazard assessment and not simply rely on secondary information. The EngD research is largely concerned with humanitarian and development NGOs owing to the fact that they are major actors in DRR and because CAFOD is involved in humanitarian and development work.

### 2.1.1 A brief history of NGOs

Civil society concerns the manner in which citizens organise themselves to an agreed purpose to improve, regulate or change society and NGOs represent one sector within civil society (Thompson, 2012). Barrow and Jennings (2001) argue that 'war has been a characteristic impetus to the formation of an NGO' (2011: 11) and that NGOs emerged in order to provide for those affected by the breakdown of government-provided systems, becoming increasingly political in their 'enunciation of their ideologies' (Barrow and Jennings, 2001). However, the emphasis on emergency relief remained the focus until the 1940s and 1950s and it was not until the 1960s that the more strident political tone was adopted owing to development discourse entering the NGO sector (Barrow and Jennings, 2001). With the retreat of the state (and particularly the fall of the Soviet Union), aid agencies and governments encouraged NGOs to provide welfare services (Benson et al., 2001). The consequential increased proportion of aid being channelled to and through NGOs led to a rapid increase in the number and size of NGOs in the 1980s, with a resounding emphasis on development, welfare services and emergency relief (Tvedt, 1998; Barrow and Jennings, 2001; Benson et al., 2001; Hilhorst, 2003; Mercer, 2006). The earliest effective developing country NGOs were in south and east Asia and within a number of countries in Latin America (Barrow and Jennings, 2001). In the context of DRR, community preparedness work grew in the 1980s and early 1990s, particularly in those countries prone to multiple hazards and with large civil societies, such as Bangladesh, the Philippines and Nicaragua (Thompson, 2012). The initiatives and thinking around social justice, partnership and social change, which emerged during the 1970s and 1980s, provided the foundations for current DRR work by civil society organisations (Barrow and Jennings; Thompson, 2012).

Institutional donors and the United Nations rely heavily on NGOs as implementing partners in humanitarian operations (Benson et al., 2001). Consequently, many NGOs rely on institutional funding to support their operations. The NGO sector is increasingly recognised amongst a number of stakeholders (including the general public) as an effective means of implementing development and relief (Benson et al., 2001; Barrow and Jennings, 2001). They are understood to work with those most in need, adopt a participatory approach (see section 2.3.4), make long-term commitments, operate flexibly and cost-effectively, address emerging issues in an innovative way and empower marginalised people in policy discussions (Benson et al., 2001). The position of NGOs to provide assistance in areas of political instability, given their ability to act independently of host governments, is also deemed an essential factor in their effectiveness as implementing partners (Barrow and Jennings, 2001). However, with the rapid growth of NGOs towards the end of last century, many practitioners and analysts began to critically evaluate the role of NGOs in the context of humanitarian and development work.

### 2.1.2 Criticism of NGOs

Since the end of the Second World War the large extension in development and relief aid between nations and the 'spectacular' growth of NGOs has raised concerns over the act of charity itself (Barrow and Jennings, 2001). Many social movements criticise NGOs owing to the perception that they are increasingly influenced by the neo-liberal forces acting through donors, states and multilateral institutions (Benson et al., 2001; Thompson, 2012). Related to this, Benson et al. (2001) observe several concerns facing development and relief NGOs, including how to increase and evaluate impact, accountability (particularly to beneficiaries), dealings with other actors in relief and development and the nature of partnership between 'Northern' and 'Southern' NGOs. There exist power discrepancies between NGOs based in the 'global North' and the local or national organisations that they fund (Thompson, 2012).

The role of NGOs as advocates for the populations with which they work has been questioned because these same populations may not necessarily want the NGO to represent them (Thompson, 2012). Class, power dynamics, differing concepts of authority and representation, urban/rural discrepancies and organisational culture all have a role in creating distrust between NGOs, community-based organisations (CBOs) and the population they are supposedly assisting (Thompson, 2012). Furthermore, claims to a participatory approach have been challenged (e.g. Bowman and White, 2012).

To emphasise the legitimacy of NGOs and their approaches, a number of professional standards have emerged including the Humanitarian Accountability Partnership Standard (HAP, 2010) and the Humanitarian Charter and Minimum Standards in Humanitarian Response (The Sphere Project, 2011). A number of agencies have established 'humanitarian principles', including the International Federation of the Red Cross and Red Crescent Movements' concept of 'the humanitarian imperative', which is the right to receive and offer humanitarian assistance unimpeded and not through a partisan or political act (IFRC/RC, 2003).

Another effect of the recent dissatisfaction has been to question the success of the humanitarian aid principle that it should 'do no harm' and to challenge the 'relief-development continuum' (Barrow and Jennings, 2001: 23). The principle of 'do no harm' emphasises the importance of a multi-hazard approach within NGO work, since focusing on single hazards might increase vulnerability to other hazards, for instance tropical cyclone shelters that do not account for seismic risk. The relief (humanitarian)-development continuum (or divide) is of particular interest to this research since it influences how DRR is theorised and implemented by NGOs (see Section 2.2).

Historically, relief operations were primarily concerned with the physical survival of individuals, whereas development activities were usually planned in respect of the sustainability and suitability of social and economic systems (Barrow and Jennings, 2001). The focus on humanitarian aid was not to build institutional capacity; rather, it aimed to be neutral and impartial regarding the legitimacy of competent authorities (Barrow and Jennings, 2001). In contrast, development assistance implied the need to make decisions regarding the legitimacy and desirably of different institutions, neither neutrally nor impartially (Barrow and Jennings, 2001).

For those agencies grappling with the relief-development continuum, the legitimacy of humanitarian NGOs as apolitical and neutral has been questioned internally and externally, particularly given that attention has turned to NGOs' political role in development, empowering the poorest, building on civil society, advocacy work and creating the conditions for liberal democracy to flourish (see Mercer, 2002). At the same time, humanitarian organisations have found themselves criticised for not challenging the political factors underlying crises' and sometimes for their lack of professionalism (see Benson et al., 2001).

In the 1960s, NGOs moved beyond the humanitarian emergency operations that characterised their early years. Large organisations recognised the need to address the root of the problems they were responding to and over the next two decades aid budgets were increasingly channelled to development, rather than relief, work. In the 1980s, however, there was a series of 'high-profile' emergencies resulting in a return to focus on relief into the 1990s. Benson et al. (2001) observed that the emphasis on 'complex' emergencies dominated humanitarian concerns and that development agencies were preoccupied with broader issues that arose from the post-Cold War era, meaning that 'natural disasters' were marginalised within NGO aid agendas. However, in the late 1990s and hastening in the 2000s, community-based disaster preparedness grew as a viable alternative disaster preparedness model (Thompson, 2012). Organisations gained a range of experience in DRR at this grassroots level, particularly in the context of 'mega-disasters', including Hurricane Mitch in Central America (1998), the Gujarat earthquake (2001), the Indian Ocean tsunami (2004), Hurricane Katrina (2005) and the Haiti earthquake (2010; Thompson, 2012). Given the history of responding to disasters, NGOs at times focused on the most recent or frequent disasters rather than an assessment of multi-hazard threats (e.g. Nicolas et al., 2009).

The history of NGOs is immersed in religious, political and cultural influences and each agency has different principles and values. However, as observed in the discussion above, there have been paradigm shifts that have undoubtedly influenced thinking and approaches to risk reduction, including multi-hazard approaches, across the NGO sector. These trends and paradigms also relate to the evolution of DRR. It is imperative to understand these influences and how these might have left a legacy with regard to approaches to multi-hazard assessment.

## 2.2 The history of disaster risk reduction and associated concepts

Before exploring the history of DRR, this section begins with an introduction to key terminology and justification for the adoption of certain definitions within this research.

### 2.2.1 Disaster risk reduction terminology

The United Nations International Strategy for Disaster Reduction (UNISDR) defines a disaster as:

> A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR, 2009a).

The term disaster has a number of different definitions but most writers agree that a disaster is the consequence of both a hazard (an event) and inherent characteristics that make people and places vulnerable (IFRC, 1993). The term is often defined by the application of certain criteria, for example the CRED Em-dat International Disaster Database adopts the UNISDR's categorisation of a disaster, the conditions for which are:

- ten or more people reported killed
- hundred or more people reported affected
- declaration of a state of emergency
- call for international assistance (CRED, 2012)

Historically disasters were termed 'natural' owing to focus upon the natural hazard trigger of the event. Paradigmatically, there was a shift from viewing disasters as natural to recognising that disasters only occur because of the interaction of hazards with people and associated socio-economic-political systems (Thywissen, 2006; UNISDR, 2006; Boudreau, 2009). This shift led to an emphasis upon vulnerability and a move to viewing risk as a component of hazard (H), vulnerability (V) and sometimes exposure (E) (Birkmann, 2006; Schneiderbauer and Ehrlich, 2006; Thywissen, 2006):

$$R = H \times E \times V \qquad (1)$$

Risk tends to encompass a temporal measure, in other words the likelihood or probability that an outcome might occur (UNISDR, 2009a; Mitchell and Harris, 2012).

There has also been increasing emphasis on the capacity (C) of communities to use existing resources to cope with hazards (Wisner, 2006). In the context of NGOs, the emphasis upon communities' capacity to address their risk has become a key component of risk reduction; for example, CAFOD's 2009 DRR Framework adopts the popular formulisation of risk as:

$$R = H \times V/C \qquad (2)$$

More recently, the emphasis has been increasingly shifting from vulnerability to capacity and moreover resilience. In order to understand how these terms shape understanding of disaster risk reduction, the history of these concepts and their definitions are introduced below.

**Hazards, exposure, vulnerability, capacity and resilience**

The 1979 UN workshop identified the theoretical division of cause and effect, and the application of the terms 'hazard', 'vulnerability' and 'risk' within this theoretical framework (Boudreau, 2009). Over time, the definition of each of these terms has been extensively discussed and challenged (see Crozier, 1988; Cutter, 2003; Thywissen, 2006; UNISDR, 2009a).

It is widely agreed that hazard refers to the event that has the potential to cause damage or harm (Twigg, 2004; Smith and Petley, 2009; Mitchell and Harris, 2012), and some defintions extend this to include the likelihood or probability that these events might occur (e.g. UNISDR, 2004). Hazards are often grouped into natural, technological and anthropogenic (Schneiderbauer and Ehrlich, 2006); the latter two are often classed as man-made, whilst natural hazards are at times termed environmental hazards (Smith and Petley, 2009).

Vulnerability is a contested concept, with some viewing it as a process (e.g. Cutter et al., 2008; Bahadur et al., 2010) rather than a state of being. Vulnerability was first introduced in the context of rural poverty (see Wisner et al., 2012) and what is agreed is that it is generally the poor who tend to be most vulnerable to hazards, owing to the economic pressures that force them to live in unsafe locations and conditions (Twigg, 2004; Ashdown, 2011). The definiton of vulnerability differs across the perspective of different points of view, for example social, economic and climate change (Wisner et al., 2012). Scientists and engineers are often criticised for their limited consideration of vulnerability owing to their tendency to focus on physical structures rather than people (Twigg, 2004). In disaster risk management, the focus on vulnerability came about because of recognition that disasters are not simply a product of natural hazards but instead are the consequence of social and economic failings (Wisner et al., 2004). The emphasis on vulnerability within the humanitarian and development sector is in the context of placing people at the centre of DRR (Thywissen, 2006; UNISDR, 2006; Boudreau, 2009).

Although contested, vulnerability is generally recognised as the extent to which a person, group or socio-economic structures is likely to be affected by a hazard (Twigg, 2004). One of the frameworks for understanding vulnerability and risk that underpins a lot of humanitarian and development work was developed by (Wisner et al., 2004) and distinguishes root causes of vulnerability (e.g. social and economic structures) and dynamic pressures (e.g. societal deficiencies) and fragile livelihoods and unsafe conditions (Wisner et al., 2012). Implied within this defintion, is the distinction made by a number of writers between intrinsic (internal) vulnerability and physical (external) exposure to hazard (Birkmann, 2006; Schneiderbauer and Ehrlich, 2006; Thywissen, 2006). The term exposure relates to the number of people and/or other elements at risk that can be affected by a particular event (Thywissen, 2006; Mitchell and Harris, 2012). Similar to vulnerability, the definition of capacity varies from the perspective of different disciplines; however (coping) capacity is generally agreed to refer to all the resources, assets and strengths people, society or organisations possess to cope with and recover from shocks and stresses (Wisner et al., 2004; UNISDR, 2009a; Gaillard et al., 2010).

Thywissen (2006) notes that coping capacity is difficult to differentiate from resilience but that resilience tends to be the more encompassing term, with coping capacity falling within it. The theory of resilience has been fiercely debated and here no attempt is made to fully represent the entire discourse; however, broadly, resilience is recognised as being concerned with how a system, community or individual can handle a disturbance, surprise or change, by withstanding or adapting in the face of shocks or stresses (DFID, 2011; Mitchell and Harris, 2012). In terms of risk management, resilience is increasingly being considered as managing change and thriving in the context of dynamic systems (Mitchell and Harris, 2012) and is sometimes termed as the ability to 'bounce forward' (Manyena et al., 2011). Vulnerability and resilience are at times treated as opposites (e.g. Twigg 2007; Manyena et al. 2011; see Gunderson and Holling, 2002); they can appear as opposite ends of a continuum if vulnerability is understood as a process (e.g. capacity to respond) rather than simply circumstance (Bahadur et al., 2010). Gallopin (2006) counters by arguing that resilience refers to changes from one state to another whereas vulnerability is defined within these states.

For the purposes of clarity, the definitions of the terms discussed above that will be used within this research are outlined in Table 2.1. For terms beyond these, the reader should refer to the glossary on page 8. The development of these terms over time is reflected in the overall transition from a technocratic risk management perspective to a people-centred DRR approach.

Table 2.1 Key DRR terminology

| Concept | Adopted definition |
| --- | --- |
| ***Capacity*** | All the resources, assets and strengths people, society or organisations possess to cope with and recover from shocks and stresses (Wisner et al., 2004; Gaillard et al., 2010; UNISDR, 2012). |
| ***Disaster*** | Changes and disruption that exceeds the affected society's capacity to cope (Twigg, 2004) |
| ***Exposure*** | The presence of people, livelihoods, environment, economic, social or cultural assets in places that could be adversely affected (Mitchell and Harris, 2012). |
| ***Hazard*** | A potential threat to humans and their welfare (Twigg, 2004). |
| ***Resilience*** | A highly contested term, broadly defined as how a system, community or individual can handle a disturbance, surprise or change, by withstanding or adapting to shocks or stresses (DFID, 2011; Mitchell and Harris, 2012). |
| ***Risk*** | The likelihood of a specific hazard occurring and its probable consequences for people and property (Twigg, 2004). |
| ***Vulnerability*** | The extent to which a person, group or socio-economic structure is likely to be affected by a hazard (Twigg, 2004). |

### 2.2.2 A short history of disaster risk reduction

Historically, approaches to disaster management were primarily reactionary, focused on humanitarian responses to the event, rather than reducing the risk in the periods both prior to the disaster and after the event itself. From the mid-1990s, a succession of global conventions have been influential in an international paradigm shift from simply managing disaster events to adopting a more comprehensive approach to reducing risk, addressing the root causes of vulnerability and advocating anticipative, long-term, prospective strategies to risk management (DFID, 2004; Islamic Relief UK, 2006) – more recently termed disaster risk reduction (DRR):

> [DRR is] the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards,

> lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (UNISDR, 2009a).

The United Nations (UN) heralded 1990-2000 as the International Decade for Natural Disaster Reduction (IDNDR; see UN Resolution A42/169/1987), the goal of which was the prevention and reduction of the risk of 'natural disasters' through the extensive application of science and technology (Giardini and Bashman, 1993). A survey of more than 100 academics and practitioners conducted in the 1990s indicated that sectoral, discipline-based approaches to development, and narrowing attitudes towards the natural environment, science and technology, were perceived to be factors contributing to the inability to reduce disaster losses (Haque and Burton, 2005); thus, the decade began with a largely technical and scientific focus and electorate. It gradually became apparent, however, that it was necessary to include the broader socio-economic agenda and involve political organisations (Wisner et al., 2004; UNISDR, 2009b).

During the mid-decade conference held in Yokohama, Japan, dissatisfaction emerged with the seemingly top-down, technocratic approach to disasters; as a consequence, efforts were then made to include NGOs and communities (Wisner et al., 2004). Subsequently, the current UNISDR, which was established in 2000 as a follow up to the IDNDR (UNISDR, 2009b), provided a coordinating framework to address disaster risks at local, national, regional and international levels (UNISDR, 2014a). In the aftermath of the 2004 Indian Ocean tsunami, representatives of 168 countries met in Kobe, Japan, in 2005 for the World Conference on Disaster Reduction (WCDR). The conference marked an historical turning point with the international recognition of the role of human actions in reducing risks and how NGOs, academics, governments, CBOs and individual citizens have a responsibility to increase their communities' resilience to natural hazards (Innocenti and Albrito, 2011). The WCDR encompassed the platform for what would eventually become the global consensus for DRR, the Hyogo Framework for Action (HFA), which comprises the key objectives and activities required by nations in order to reduce risk.

The HFA emphasises a multi-hazard approach across DRR policies, planning and programming (UNISDR, 2005). The framework outlines five key priorities for action to be completed during 2005-2015:

1. Ensure DRR is a national and local priority with strong institutional basis for implementation.
2. Identify, assess and monitor disaster risks and enhance early warning.
3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
4. Reduce the underlying risk factors.
5. Strengthen disaster preparedness for effective response at all levels (UNISDR, 2005: 6).

The HFA does not embody a binding agreement between countries, but it is monitored and reviewed by the UNISDR. Every two years, the Global Platform for Disaster Risk Reduction (GPDRR) assembles academics, governments, the UN, NGOs, practitioners and the private sector (UNISDR, 2012) with the mandate (imposed by the United Nations General Assembly (A/RES/62/192) to assess the progress countries are making with regard to the objectives of the HFA, whilst also providing the opportunity for delegates to share good practice and identify gaps and targeted action (PreventionWeb, 2012). With regard to HFA priority 2, a key measure of the progress reports signatory countries provide is whether they are implementing national multi-hazard risk assessments. Moreover, the Chair's Assessment of the Third Session of the GPDRR (held in Geneva in May 2011) highlights the 15 critical steps identified during the Session, two of which make reference to multi-hazards:

> 8.4 Account for disaster losses in a standardized manner to support multi-hazard, integrated assessments as the basis for development decision-making and open-source risk public information...
>
> 8.9 Identify and prepare for emerging risks, including those associated with technological hazards and pandemics, through scientifically-informed multi-hazard risk assessments and scenario development. Encourage cross-sectoral cooperation that makes best use of available information and technology (Chair's Summary, 2011:3).

The chairman's comments emphasise the need for multi-hazard assessments and that these must be underpinned by science in order to better prepare for emerging risks. These comments are also echoed in the recent Humanitarian Response Review (HERR), which states that science is required for agencies to better anticipate threats (Ashdown, 2011).

Schneiderbauer and Ehrlich (2006) note that, whilst over the last few decades the focus of disaster management research has shifted from 'hazard assessment' to 'vulnerability analysis', the determination of vulnerability and coping capacity is one of the weakest components of risk assessment. The emphasis on vulnerability appears to be in the context of both its major role in determining the cause of disasters and the perceived complexity and difficulty of its assessment (e.g. Boudreau, 2009). In 2009, however, the UNISDR Scientific and Technical Committee expressed concern that such shifts have been accompanied by decreasing recognition of the role of science and technology – and the hazard component (UNISDR, 2009c). Within its report it is noted that natural hazards are insufficiently studied in many regions, as exemplified in the findings of the recent Volcanic Risk Study compiled as part of the Global Facility for Disaster Risk and Recovery Programme (Aspinall et al., 2011). Furthermore, the HFA mid-term review raises concerns regarding the identified lack of systematic multi-hazard assessments (Louw et al., 2011).

Many governments and NGOs have been attempting to integrate DRR into their short-term humanitarian response to disasters and their long-term development programmes. However, with the growing acceptance of the threat of and need to adapt to climate change, policy makers have begun to question whether DRR is sufficiently equipped to address emerging threats. There is growing concern that climate change may increase vulnerability through both the intensification of meteorological hazards and through the long-term changes in the global climate (DFID, 2004; see Schipper and Pelling, 2006; UNISDR, 2009b). As a reaction to this concern, the concept of climate change adaptation (CCA) has rapidly taken shape and increased in importance. It is, therefore, necessary to briefly review CCA since the debate surrounding where it overlaps with DRR provides important context to the humanitarian and development sector and perceptions of hazard and risk by NGOs.

### 2.2.3 Overlapping concepts: DRR and CCA

Following the release of the International Panel on Climate Change's (IPCC) fourth assessment report (2007), adaptation to climate change emerged as a necessary field of engagement both for developed and developing countries (Innocenti and Albrito, 2011). The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change adaptation as:

> [the] [a]djustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (2014).

The necessity of integrating CCA into strategies and decision-making processes for development has been emphasised by the acknowledgement that development and CCA are interlinked (Olhoff and Schaer, 2010), and the perception of an increase in climate-related disasters (Mitchell et al., 2010a). Being both a political and practical issue, and with the increasing number of funding opportunities for CCA initiatives, there is growing advocacy for the integration of DRR and CCA (Mitchell and van Aalst, 2008; Venton and La Trobe, 2008; UNISDR, 2009b; Mercer, 2010; Mitchell et al., 2010b). Points of convergence and divergence span international agreements and financial mechanisms to practical applications (Mitchell et al., 2010b; Table 2.2). The following discussion does not attempt to address the entirety of this extensive debate but instead focuses upon those elements that relate to how humanitarian and development NGOs perceive hazards and risks. Two key perceived distinctions between DRR and CCA, which appear to underpin much of the debate, are scale and type of hazard (Venton and La Trobe, 2008; Romieu et al., 2010).

Table 2.2 Conceptual and practical differences between CCA and DRR updated from Venton and La Trobe (2008) by Mitchell et al. (2010b). Source: (Mitchell et al., 2010b; Table 2: 8).

| Differences | | Signs of convergence |
|---|---|---|
| DRR | CAA | |
| Relevant to all hazard types | Relevant to climate and weather-related hazards | DRR programmes have always considered weather-related hazards but there are indications that some are now taking into account the impact of climate change on hazard frequency and magnitude and on vulnerability and planning interventions accordingly |
| Practice of DRR strongly influenced by post-disaster humanitarian assistance | Origin and culture of CCA derived from scientific theory and international climate change policy processes | Common ground being found in joint mainstreaming into development sectors – so specialists on both adaptation and DRR working in infrastructure, water/ sanitation, agriculture and health for example. |
| Most concerned with the present and near future: addressing existing risks based on assessment of local experience and historical record, for example | Most concerned with the short, medium and long-term future – addressing uncertainty and new risks derived from the impacts of climate change | DRR increasingly forward-looking and CCA increasing using and existing climate variability as the entry point for activating adaptation processes. The idea of 'no regrets' options is a key area of convergence. |
| Traditional and local knowledge is the basis for community-based DRR and resilience building | Widely held view that traditional and local knowledge at community level may be insufficient as impacts of climate change introduces new risks and changes to the frequency and magnitude of existing hazards. However, increasingly recognised that local knowledge also includes people's ingenuity in facing risks. | Growing number of examples where local knowledge and meteorological/ climatological knowledge being considered side-by-side to inform DRR interventions |
| Traditionally has considered risk a function of hazard, vulnerability, exposure and capacity | Traditionally has treated vulnerability interchangeably with physical exposure | IPCC special report on 'managing the risks of extreme events and disasters for advancing adaptation (due in 2011), promises convergence in this area |
| Full range of established and developing tools | Range of tools under development | Significant progress made in integrating learning from DRR into adaptation tool development |
| Incremental development, moderate political interest | New, emerging agenda, high political interest | Disasters more often seen as linked to climate change, and governments recognising the need to consider both simultaneously |
| Funding streams often ad hoc, unpredictable and insufficient | Funding streams increasing and promise to be considerable, though problems of delivery and implementation widespread | DRR community demonstrating signs of being increasingly savvy in engaging in climate change adaptation funding mechanisms |

Both DRR and CCA aim to reduce the impacts of shocks by anticipating risks and uncertainties and addressing vulnerabilities (Mitchell et al., 2010). Climate change is anticipated to affect disaster risk through the probable increase in meteorological disasters and through increasing vulnerability of communities to natural hazards (DFID, 2004) through, for example ecosystem degradation or long-term nuances in global and local economies (see Schipper and Pelling, 2006; Pelling, 2011). At the same time, however, the perceived increase in the frequency of climate-related disasters (Mitchell et al., 2010a) is resulting in greater emphasis being placed upon CCA, at the expense of DRR, within the humanitarian and development sector. In contrast, the framework for DRR is struggling to demonstrate success (Louw et al., 2011).

DRR and CCA have emerged from different disciplines (humanitarian response and environmental science respectively) and this separation is maintained by the perception that there are two key distinctions between DRR and CCA: the temporal and geographical scales which are addressed and the type of hazard considered (Venton and La Trobe, 2008; Romieu et al., 2010). DRR is perceived to adopt a short-term, local, perspective whereas CCA tends to be described as adopting a long-term, global, perspective (e.g. Sperling and Szekely, 2005; Few et al., 2006). However, the lack of local level information and data (Romieu et al., 2010) and the associated uncertainty (Prabhakar et al., 2009) means that CCA lacks context and the local, bottom-up perspective inherent in NGO approaches to DRR (Mercer, 2010).

In 1999, Burton and van Aalst suggested that a 'full risk analysis' of development projects was needed, which addresses natural hazards as well as increases in risk due to climate change over the life-time of a project (Sperling and Szekely, 2005). However, a number of authors have justified a distinction of separate communities of practice by arguing that DRR addresses all natural hazards, thus making it beyond the remit of CCA, which is perceived to address adaptation to the changing nature of meteorological hazards and long-term climate change (e.g. Venton and La Trobe, 2008). As such, some DRR specialists are sceptical of the adaptation community's perceived focus on a long-term agenda that only encompasses part of the entire array of hazards (Mitchell et al., 2010). Some DRR writers suggest that a long-term perspective is an inherent component of DRR (Kelman and Gaillard, 2008; Mercer, 2010), owing to its requirement to be integrated in development planning (DIFD, 2004).

However, it is implied that most contributors to the integration debate do not believe that DRR has brought about the adoption of a long-term perspective in practice (e.g. McBean and Ajibade, 2009; Birkmann and von Teichman, 2010). Furthermore, in spite of a conceptual claim that CCA addresses long-term vulnerability and gradual, creeping change (Romieu et al., 2010) current practice is to address existing climate variability as a practical approach to CCA, owing to the assumption that by coping better with existing risk, it may be possible to reduce risk to long-term climate change (Sperling and Szekely, 2005; Schipper and Pelling, 2006; Thomalla et al., 2006; Tanner and Mitchell, 2007).

Given that, in actuality, both DRR and CCA are only addressing risk in the short-term, it is questionable whether NGOs are fully appreciating the dynamic nature of hazards over time. Within the integration of DRR and CCA debate, there is some recognition that the components of risk require regular revision due to the dynamic nature of risk in general (Dilley, 2006; Tanner and Mitchell, 2007; Birkmann and von Teichman, 2010). However, the emphasis on the changing nature of hazards tends to be in the context of climate change:

> in contrast to geological disasters, it is important to ensure that current disaster prevention efforts aimed at weather related events have the built-in capacity to accommodate changes in frequency and magnitude over time (Sperling and Szekely, 2005: 28).

In stating the above, Sperling and Szekely (2005) are apparently making the assumption that only meteorological events are variable over time. There is a growing emphasis within the CCA discourse, however, on the fact that the climate system is nonlinear and thus building resilience does not simply encompass addressing the uncertainties surrounding changes to existing climatic threats, but also necessitates addressing emergent, unanticipated risks (CCCD, 2009). The supposition is that DRR is more likely to struggle to integrate risks that are yet to be experienced, whereas this is a core component of CCA (Venton and La Trobe, 2008; McBean and Ajibade, 2009). However, there is a growing emphasis within the humanitarian discourse on better anticipation of hazards and disasters in general (e.g. Ashdown, 2011). The 2011 Global Assessment Report notes that a growing number of potential and plausible risks are either difficult to assess or have severe impacts due to the growing interconnection and interdependency of modern societies:

> As such, there is a growing probability of 'simultaneous crisis' where different hazards occur at the same time, 'sequential crisis' where hazards trigger cascading disasters in a range of interlocked systems, and 'synchronous failures' where different risks converge and interact (UNISDR, 2011:7).

The appreciation of the complexity of disasters, the interrelatedness of hazards and the compounding effects of environmental degradation is growing amongst DRR actors (e.g. UNISDR, 2004; FIC, 2010), typically manifesting through concerns regarding the uncertainty of what the future may bring and over the disaster 'surprises' of the recent past (e.g. the 2010 earthquake in Haiti and the 2011 earthquake, tsunami and nuclear reactor failure in Japan). Whilst humanitarian organisations have become more conscious of vulnerability and its root causes, the separation of natural hazards (DRR) from climate change hazards (CCA) means that in some cases climate change is taking precedent over DRR. DRR proponents argue that CCA must be mainstreamed within DRR since it has established and applicable methods and tools (Prabhakar et al., 2009; Birkmann and von Teichman, 2010; Gaillard, 2010; Mercer, 2010). Rowling's (2008) interviews with NGOs found that, whilst respondents adopted a variety of lenses, almost all linked their work on DRR with climate change; but, although some assumed that climate change in practice was interchangeable with DRR work, others argued for a necessary clear distinction (Rowling, 2008). Thus, both the DRR and CCA communities seem reluctant to fully integrate – a need for 'convergence but not conflation' (Harris and Bahadur, 2011: 6). This situation has consequently created an inefficient approach to visualising risk, one which does not readily reflect the views of those at risk; for example communities tend to view hazards, risk and the environment holistically (Mercer, 2010). Mitchell and van Aalst (2008) note that the driver for closer integration between DRR and CCA has grown from the implementation side, with projects attempting to tackle the full spectrum of risk. Some advocate CCA as the platform to move away from the current compartmentalised approach to addressing risk (Harris and Bahadur, 2011), but, more recently, DRR and CCA have been increasingly converging through their common goal of building resilience to shocks and stresses.

The above discussions have highlighted that there are different paradigms for framing hazards and risk currently being adopted in the humanitarian sector, which make reference to multi-hazards. However, multi-hazard is concept that has never received the same level of attention, despite its frequent appearance across policy and strategies for risk reduction. It is, therefore, necessary to elucidate the concept of multi-hazards and strategies for their assessment.

## 2.3 Multi-hazard concepts and their assessment

Multi-hazard does not constitute a new term; it was emphasised by the United Nations Environment Programme (UNEP) in 1992 through their recognition that one type of risk reduction could possibly increase vulnerability to other risks (UNEP, 1992). Furthermore, the Johannesburg Plan of Implementation (see the 2002 World Summit on Sustainable Development and the subsequent Millennium Development Goals) included government pledges to an inclusive, integrated and multi-hazard approach to tackle vulnerability, risk assessment and disaster management (ICSU, 2008). Thus, multi-hazard understanding has historical foundations within the environment and development discourse. In the context of DRR, it is included in a number of international agreements, notably emerging within the general considerations of the HFA (UNISDR, 2005). The Fourth Asian Ministerial Climate Change Conference held in Incheon, South Korea (October 2010), emphasised the role of multi-hazard assessments in the context of raising awareness and capacity for DRR and CCA (AMCDRR, 2010). Even prior to the introduction of the term DRR, multi-hazards were discussed in the context of emergency planning (e.g. Foster, 1980), challenging the notion that traditional disaster management only considered a mono-hazard approach. There is, therefore, general recognition across policy that DRR should incorporate a multi-hazard approach (DFID, 2004; Ashdown, 2011; UNISDR, 2011; Shepard et al., 2013).

In spite of advocating the need for multi-hazard approaches, the majority of assessments are concerned with single hazards (Kappes et al., 2010; Tweed and Walker, 2011). Furthermore, and contrary to most terms within the DRR lexicon (see Thywissen, 2006), inadequate attention has been paid to the concept of 'multi-hazard' and what is required of a multi-hazard assessment.

### 2.3.1 The concept of multi-hazard

The concept of multi-hazard is becoming increasingly prevalent in hazard and disaster studies, especially within spatial planning (e.g. Greiving et al., 2006; Schmidt-Thome, 2006; Delmonaco et al., 2007), but most studies remain fairly limited and primarily focus on discrete hazards (Schmidt-Thome, 2006; Kappes et al., 2010; Tweed and Walker, 2011). Further limitations have come about owing to the fact that hazard analysis has traditionally been discipline specific (e.g. seismology) and natural hazards are readily categorised into typologies, such as geophysical, meteorological, hydrological and climatological (see Table 2.3).

Table 2.3 Disaster Subgroups as described by Guhar-Sapir et al. (2011). The table is adapted from Table 1 (pg. 7) in the original document – the Biological sub-group is omitted since it is not considered within the context of this study. Source: Guhar-Sapir et al. (2011: 7).

| Disaster Subgroup | Definition | Disaster Main Types |
|---|---|---|
| ***Geophysical*** | Events originating from solid earth | Earthquake, Volcano, Mass Movement (dry) |
| ***Meteorological*** | Events caused by short-lived/small to meso scale atmospheric processes (in the spectrum from minutes to days) | Storm |
| ***Hydrological*** | Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up | Flood, Mass Movement (wet) |
| ***Climatological*** | Events caused by long-lived/meso to macro scale processes (in the spectrum from intro-seasonal to multi-decadal climate variability) | Extreme Temperature, Drought, Wildfire |

There has been increasing recognition that multi-hazard analysis also requires an understanding of the interdependencies across hazards (Ashdown, 2011). However, there remains neither a uniform conceptual approach nor agreed and standardised terminology of these interdependencies (Kappes et al., 2012; see Table 2.4).

Terms such as compound hazards, interactions, interrelations, or synergic effects are not particularly explicit and obvious (Kappes et al., 2012). In contrast, one type of phenomena can be clearly distinguished: the triggering of one hazard by another. This triggering is sometimes termed a 'cascade effect' – when an 'adverse event' triggers one or more 'sequential' ('synergistic') events, resulting in a chain of hazards (Marzocchi et al., 2009). Delmonaco et al. (2006: 10) equates these chain events to the domino effect or cascading failure in a system of interconnected components, where the service provided depends on the operation of a preceding component and, as such, the failure of a preceding part can trigger the failure of consecutive parts. The need to anticipate these connections was particularly recognised after the 2011 Tōhoku earthquake and tsunami in Japan (Tweed and Walker, 2011).

Table 2.4 The terms used to describe the relations between hazards and different hazard processes. Source: Kappes et al. (2012: 11). The original table has been reproduced for clarity. See Kappes et al. (2012) for the references listed below.

| ***Terminology*** | ***Author*** |
|---|---|
| *Cascades, cascading effects, cascading failures or cascade events* | Delmonaco et al. (2006b), Carpignano et al. (2009), Zuccaro and Leone (2011), European Commission (2011) |
| *Chains* | Shi (2002), Erlingsson (2005) |
| *Coincidence of hazards in space and time* | Tarvainen et al. (2006) |
| *Coinciding hazards* | European Commission (2011) |
| *Compound hazards* | Hewitt and Burton (1971), Alexander (2001) |
| *Coupled hazards* | Marzocchi et al. (2009) |
| *Cross-hazard effects* | Greiving (2006) |
| *Domino effects* | Luino (2005), Delmonaco et al. (2006b), Perles Roselló and Cantarero Prados (2010), European Commission (2011) |
| *Follow-on effects* | European Commission (2011) |
| *Interactions* | Tarvainen et al. (2006), dePippo et al. (2008), Marzocchi et al. (2009), Zuccaro and Leone (2011) |
| *Interconnections* | Perles Roselló and Cantarero Prados (2010) |
| *Interrelations* | Delmonaco et al. (2006b), Greiving (2006) |
| *Knock-on effects* | European Commission (2011) |
| *Multiple hazard* | Hewitt and Burton (1971) |
| *Synergic effects* | Tarvainen et al. (2006) |
| *Triggering effects* | Marzocchi et al. (2009) |

Understanding of the relations between hazards can be derived from existing hazard disciplines. For instance, landslides can be considered as primary, secondary and tertiary hazards in the sense that they can be triggered by non-hazardous and hazardous phenomena, as well as lead to subsequent hazards (e.g. damning of rivers and subsequent flooding; Catane et al., 2012). Lee and Jones (2004) distinguish three multi-hazard characteristics of landslide events: compound events (cascade of different types of landslide); multiple events (widespread landslide activity) and complex events, where part of the damage emanates from the generation of secondary geohazards, such as floods, tsunamis or volcanic eruptions.

Similarly, volcanology inherently adopts a multi-hazard approach. Most eruptions are accompanied by several different hazards; phreatic and magmatic eruptions may produce tephra fall, pyroclastic density currents, lava flows, blasts, sector collapses, gas emissions, landslides, rockfalls, lahars, floods, earthquakes and tsunamis (Neri et al., 2013). Volcanoes often interact with other hazards; in the Philippines, the 1991 eruption of Mt Pinatubo is believed to have been related to the preceding 1990 Luzon earthquake (Bautista et al., 1996) and in tropical environments volcanoes frequently interact with typhoons to create lahars (e.g. Mt Mayon in the Philippines – see Paguican et al., 2009). It is therefore necessary to also consider the adverse events that may occur during both periods of rest and unrest when adopting a multi-hazard approach (Neri et al., 2013).

Marzocchi et al. (2009) highlight that understanding hazard chains is an essential component of multi-hazard analysis since the overall measure of hazard and risk of causally connected processes may be much higher compared with an assessment which only measures the aggregation of what are perceived to be independent hazards. Kappes et al. (2010) note that the difficulty of Marzocchi et al.'s (2009) definition is that it implies that the triggering event needs to be a hazard when in fact processes may themselves not cause damage but still act as triggers of more than one hazard.

Woo (1999) has emphasised the importance of distinguishing between 'causative' events and 'trigger' events. He argues that causative events and possible consequences are defined by the fact that the relationship between the two types of event is physically apparent and that a good understanding exists of the precise dynamical mechanism of causation (e.g. a landslide damming a river which subsequently causes flooding). Woo (1999) notes the significance of 'extraneous factors' which may be paramount in creating an environment conducive for the occurrence of the secondary event. In the case of trigger events, the association is more physically tenuous and the precise dynamical mechanism of trigger is obscure. In this situation, Woo (1999) notes that the environment must be in a 'critical dynamic state of preparedness'; for example whilst an earthquake may not be the direct cause of a volcanic eruption or another earthquake, it may alter stress in the crust so as to precipitate the occurrence of further regional geological events (e.g. McCloskey et al., 2005), thus arguably increasing the probability a second event. However, as noted by Woo, much uncertainty resides in determining the transition from mere association to clear causality (Woo, 1999). Thus, these two processes shall be distinguished as causation (as defined by Woo, 1999) and association (Woo's, 1999, 'trigger').

Hazards can also be interrelated through the influence of one hazard on the susceptibility of a future hazard (Kappes et al., 2012). In their analysis of tsunami hazard in Sri Lanka, Garcin et al. (2008) observe the amplification of hazards through positive feedback; the impact of tsunamis can alter coastal morphology and the coastline, consequently influencing processes of erosion, transportation and sedimentation resulting in a modification of the erosion hazard and morphology of the coastal zone. Such changes in the near-shore bathymetry will affect the tsunami hazard, which will in turn alter coastal morphology (Garcin et al., 2008). Independent hazards can also influence the conditions for the occurrence of subsequent hazards, for example the influence of forest fires on flooding owing to the formers destruction of vegetation cover and, consequently, the removal of this hydrological and soil protection (Bovoloa, 2009).

The above discussion demonstrates the temporal and spatial interdependency of hazards (Marzocchi et al., 2009; Kappes et al., 2010; Table 2.5). As a consequence of these interdependencies, hazard interrelations do not simply relate to processes of linear cause and effect but that two or more hazards could simultaneously occur and produce compounded effects and/or secondary events (e.g. an eruption and a typhoon resulting in lahars).

Table 2.5 The types and effects of hazard relations conceptually determined by Kappes et al. (2011), emphasising the spatial and temporal dimensions of hazard interdependencies. Source: Kappes et al. (2011, Table 3: 582).

Types and effects of hazard relations on the resulting vulnerability.

| | Spatially overlapping | Spatially not overlapping |
|---|---|---|
| Not simultaneous | Elements are affected by different hazards at different times (1) | Different elements within the area under consideration are affected by different hazards at different times (2) |
| Simultaneous or timely close | Element are affected by two hazards at the same time (3) | Different elements are affected at the same time by different hazards (4) |

Multi-hazard, by accounting for the interdependencies between hazards, should comprise more than simply the aggregated analysis of individual hazard assessments – it should encapsulate the amplification of events, 'cascading' events and the temporal coincidence of events in time and space. In light of the review of the literature, the following conceptual framework for multi-hazards is proposed. The concept of multi-hazard is defined as comprising two key components, which require determination through an analysis of varying temporal and spatial scales:

(1) more than one hazard

(2) interrelations between hazards

Within this conceptual framework, four categories of hazard interrelations are proposed (Table 2.6). It is necessary to emphasise that each of these is not mutually exclusive; in particular, there is a continuum between causation and association (event that leads to another event), and coincidence and amplification (factors that enhance the magnitude and impact of the event). These interrelations manifest as simultaneous and/or cascading hazard events in space and time.

Table 2.6 Categories of hazard interrelations.

| ***Category*** | ***Working definition*** | ***Example*** | ***Examples of related work*** |
|---|---|---|---|
| ***Amplification*** | Hazards that exacerbate future hazards (applies to the same or different hazards). | The effect of coastal erosion on the impact of coastal flooding and tsunami inundation. | Garcin et al., 2008; Bovoloa, 2009; Kappes et al.'s (2012) concept of 'disposition'. |
| ***Association*** | Hazards that increase the probability of a secondary event, but which are difficult to quantify. | Stress transfer along faults. | Woo's (1999) 'trigger'. |
| ***Causation*** | Hazards that generate secondary events, which may occur immediately or shortly after the primary hazard (including cascading hazards). | An earthquake triggered landslide. | Kappes et al. (2010); (Marzocchi et al., 2012b); Woo's (1999) 'causative' events. |
| ***Coincidence*** | The simultaneous (or closely timed) occurrence of hazards in space and time, resulting in compounded effects or secondary hazards. | The coincidence of a windstorm with a volcanic eruption (lahar hazard) or an earthquake (firestorm hazard). | Kappes et al. (2011); Marzocchi et al. (2009). |

There is a lack of systematic guidance for governments and NGOs as to how they might undertake multi-hazard risk assessments that account for the processes discussed above; for example, in spite of the DFID's recommendation of multi-hazard risk assessments as a key step in embedding resilience in their work, their guidance as to how to implement these assessments is fairly vague and does not readily bring out the complexities of multi-hazard risk assessment (see DFID, 2012). As such there is a need to explore practical methods of assessing multi-hazards. The following discussion, therefore, builds upon the work in hazard and risk assessment research more widely, before introducing NGO approaches to hazard assessment.

### 2.3.2 Approaches to multi-hazard assessment

The essence of most multi-hazard assessments at local and global scales is the adoption of a 'more than one' hazard approach, which is achieved by aggregating or comparing the results of individual hazard assessments, but does not consider the interdependencies between the hazards (e.g. DFID, 2004; Greiving et al., 2006; Stanganelli, 2008; DFID, 2012). In order to make decisions regarding risk reduction strategies based on the assessment of multi-hazards, it is deemed necessary to categorise individual hazards into hazard classifications, for example low to high hazard (e.g. UNISDR, 2004; Schmidt-Thome, 2006; Bovoloa, 2009; Mosquera-Machado and Dilley, 2009; Peduzzi et al., 2009; Kappes et al., 2010; Kappes et al., 2012). However it is difficult to compare these hazards since the criteria applied most likely differ (Kappes et al., 2011).

Hazards have different characteristics and their impacts on elements at risk differ (Kappes et al., 2012). In order to combine hazards, it is therefore necessary to identify a common reference point, for example a vulnerability index or a damage scale rating (e.g. Grünthal et al., 2006), which is usually weighted in accordance with the influence of each hazards using a method of expert elicitation (e.g. Kappes et al., 2011). Once risk is determined per hazard, these are either compared or often combined to determine the aggregated multi-hazard risk (e.g. Dilley, 2006). The results of assessments are often presented spatially using, for example, geographic information systems (GIS; e.g. Thierry et al., 2008). UNISDR (2004) and Stanganelli (2008) suggest that GIS techniques have broadened the possibilities to undertake multi-hazard assessments; however, GIS does not comprise a methodology for assimilating the hazard parameters and assigning and predicting the interactions between hazards. Kappes et al. (2010) suggest, however, that in overlaying maps qualitative inferences can be made about interdependencies, specifically amplification effects, and that these can be supported by more sophisticated event trees and probabilistic scenarios.

Interaction matrices have also been used to identify relations between hazardous processes and can be utilised to determine the location of these interactions by overlaying spatial information (Kappes et al., 2012). In general, these relations are qualitative or semi-quantitative; for example Tarvainen et al. (2006) present the summarised list of the 'interactions' of fifteen different hazards in a matrix according to the following scheme: 1 = existing influence of a hazard on the other hazard; 0 = no physical influence of a hazard on the other hazard. In the case of 'vice versa' interactions (e.g. earthquakes - volcanic eruptions), the interaction is counted twice. Interactions were only considered when the hazard intensities in a certain region were above a defined threshold, which is intuitive since there may be some interactions that will only occur given a certain intensity (e.g. earthquake triggered landslides). Whilst such an exercise allows for the identification of the influencing dominance of certain hazards on others (see Tarvainen et al., 2006), matrices like that of De Pippo et al. (2008) assume a linear process of cause and effect rather than accounting for the compounding effect of more than one hazard and the secondary hazards this 'interaction' might trigger. The use of the term 'interaction' is confusing because it suggests a mutual influence between two processes, but in the case of these matrix examples it has been used to describe linear cause and effects (Kappes et al., 2012).

Another means of quantifying multi-hazard chains has come from volcanology. Assessing eruption risk scenarios in a probabilistic manner has become one of the major challenges of modern volcanology because of the need to assess the relative likelihoods of different ways in which a volcanic system may evolve in the future or during real-time volcanic activity (Martí et al., 2008). This situation is compounded by the difficulty of communicating this information to the corresponding decision-makers, without losing essential information (Martí et al., 2008). To this end, and more recently for the assessment of hazard interrelations (see Lacasse, et al., 2008; Marzocchi et al., 2009), event-trees of impact scenarios have been generated (Newhall and Hoblitt, 2002; Neri et al., 2013). An event tree is defined as:

A graphical, tree-like representation of events in which branches are logical steps from a general prior event through increasingly specific subsequent events (intermediate outcomes) to final outcomes (Newhall and Hoblitt, 2002: 3-4).

In comparison with event trees applied in volcanic settings (see Figure 2.1), event trees for multi-hazards may start with a number of branches and slowly focus towards a single outcome, for example in the case of multiple triggers for an event (e.g. landslides).

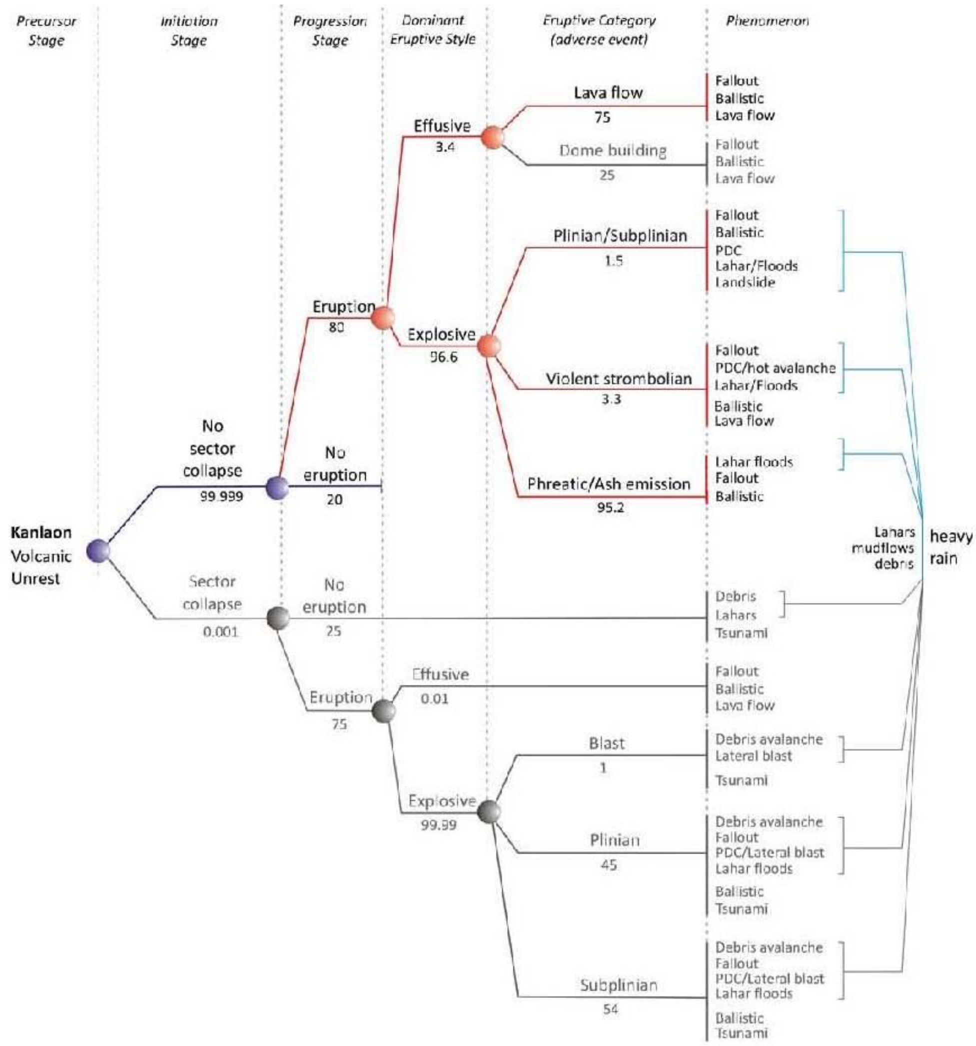


Figure 2.1 Type of hazardous events and their possible frequencies at Kanlaon volcano in the Philippines. Grey branches represent activities that occur so rarely that it is not possible assign reliable statistical calculations. Source: Neri et al. (2013: 1937).

The branches of the event-tree are weighted probabilistically through either statistical analysis of historical or geological data, or by elicitation of expert judgement (Aspinall and Cooke, 1998; Lacasse et al., 2008). There is difficulty in assigning probabilities and uncertainties to the array of possible futures that might present themselves (Allen, 1998). The branches of the event tree can, however, be a useful means of checking the relative probability of events (e.g. Marzocchi et al., 2009) and identifying whether 'known' probabilities require revision.

The concept of multi-hazards has been demonstrated to include a number of components, including a complex set of interrelations between hazards that can be characterised over time and space. Kappes et al. (2012) state that:

> A multitude of methodologies and approaches is emerging to cope with [the] challenges [of assessing multi-hazards], each with certain inherent advantages and disadvantages. Whatever approach is chosen, it has to be adjusted according to the objectives (e.g. what results are required) and to the inherent issues (e.g. stakeholder interests), respectively. (2012: 28)

There is therefore an emphasis on the requirements of the end-user as a means of determining appropriate approaches (Marzocchi et al., 2009), which also implies that it might be challenging to propose a standardised approach to multi-hazard analysis. In order to determine a suitable method, Kappes et al. (2012) propose that two principal choices have to be made: (1) whether a multi-hazard or multi-hazard risk outcome is desired and (2) whether a qualitative, semi-quantitative or quantitative outcome is required. From Kappes et al.'s (2012) review it appears that multi-hazard risk is more appropriate when comparing hazards, whereas multi-hazard analyses have tended to explore scenarios of interacting and cascading hazards. These two choices emphasise that selecting the appropriate approach is not only dependent on the research objective, but also on the availability of data (Kappes et al., 2012).

In spite of the general agreement of the need for multi-hazard assessments, there are few that take account of both multiple and interrelated hazards (Schmidt-Thome, 2006; Kappes et al., 2010). This may in part be due to the single-discipline approaches to hazard science which traditionally dominate scientific research (Stanganelli, 2008; see Checkland, 1999), compounded by the difficulties of defining academic excellence within interdisciplinary multi-hazard research (Darnell, 2009). Furthermore, the scarcity of analyses of multi-hazard interrelations may be a manifestation of a reluctance to attempt multi-hazard assessments owing to the perceived array of identified difficulties in doing so (Tweed and Walker, 2011). Maps, matrices and event trees represent tools for identifying and visualising possible connections across hazard, but the means of anticipating these is reliant on a combination of statistical analysis and expert judgement. As such, the quantification of hazard interrelations depends on the availability of data and expertise. This might be problematic for developing country contexts where data and expertise may be lacking.

### 2.3.3 Knowledge and expertise for assessing multi-hazards: the role of science and community-knowledge

Multi-hazard disaster risk management is a complicated area necessitating expert knowledge and practical experience from a range of disciplines (Tweed and Walker, 2011) and a methodology to collate this information in a participatory manner (Ritchey, 2006). In the DRR policy, there has been a recent emphasis on the role of scientific expertise for risk reduction, along with recognition of the key role of knowledge provided by communities at risk (Twigg, 2004; Mercer et al., 2009; Gaillard, 2010; Ashdown, 2011). This is also recognised in the context of multi-hazards:

> A holistic, all-hazard, risk-based and problem-solving approach should be used to address the multifactorial and interdependent nature of the disaster risk chain and to achieve improved [DRR]. This requires the collaboration of all stakeholders, including suitable representatives of governmental institutions, scientific and technical specialists and members of communities at risk. By working in partnership to share the outputs of scientific research, and by building

> translational science – motivated by the need for practical applications…[DRR] decision-making will be more easily informed (Southgate et al., 2013: 34).

The UNISDR omit NGOs in the last quotation, despite their being key actors in community-based DRR and emergency response. If NGOs wish to adopt an 'all-hazard' approach, then the implication is that they must also partner with scientific and technical specialists.

The type of knowledge utilised for the purposes of DRR is often subdivided into 'scientific' (natural or physical) and/or 'technical' knowledge (outsider knowledge) and 'indigenous' (or 'local') knowledge (insider knowledge). Science can be defined as the 'the systematic study of the structure and behaviour of the physical and natural world through observation and experiment' (Soanes and Stevenson, 2009). Scientific knowledge is often termed as 'Western' technology or techniques (Mercer et al., 2009; Mercer, 2012), although arguably such a categorisation is dismissive and disempowering of the influence of scientists within developing countries. Mercer et al. (2010) summarise the relevant literature in their definition of indigenous knowledge as:

> a body of knowledge existing within or acquired by local people over a period of time through accumulation of experiences, society-nature relationships, community practices and institutions, and by passing it down through generations (Mercer et al., 2010: 217).

Shaw et al. (2009) make a distinction between indigenous technical knowledge (for example the use of fertilisers) and indigenous knowledge (for example folk songs for raising awareness), characterising the latter as being specific to a culture, context and community and typically regarded as informal knowledge, which is generally orally transmitted and not documented – in other words tacit knowledge (Mercer, 2012). Knowledge derived from local communities is referred to as 'community' knowledge in this thesis, owing to the application of hazard assessment at the community level. Whilst the notion of community is contested, given its use in NGO literature it is here used to imply the local level analysis employed by NGOs.

To some extent, scientific and community knowledge are interdependent – actors are part of the system such that as scientists develop data on the effects of global climate change, for example, people's perceptions are altered and social practices change (Allenby, 2007). In spite of this, there is the tendency to polarise science – social scientists define science as outsider knowledge (e.g. Mercer, 2012); however, some scientific methods, such as river level monitoring, can be implemented by local communities. Whilst a number of writers acknowledge the benefits of indigenous knowledge, there is also the danger of romanticising it and treating local knowledge as harmonious when in reality there are widespread conflicts among local groups over knowledge (McIlwaine, 2006; Bowman and White, 2012). At the same time, natural and physical scientists have a history of defining themselves as 'pure scientists' rather than as 'honest brokers' (see Pielke, 2007), and are perceived to have historically downplayed the potential of community knowledge (Mercer et al., 2009; Gaillard, 2010) because science mirrors the historical institutional top-down approach that favoured hazard analysis over vulnerability assessment (Mitchell, 2006).

Much of the hazard science and risk expertise has historically focused on understanding discrete hazards, rather than on their interaction. Tweed and Walker (2011) argue that knowledge applicable to a 'mono'-hazard case studies does not readily apply to multi-hazard settings in which 'interconnection and interdependency complicate likely hazard scenarios' (2011: 939). Furthermore, traditional research and scientific approaches have been criticised for not adequately responding to the problems of modern society (Hjorth and Bagheri, 2006). The response from scientific groups is to broaden their definition of science to recognise natural, physical and social sciences (e.g. ICSU, 2008). Policy makers have moved to refocusing on science in the context of DRR; for example, the UNISDR Science and Technical Advisory Group has deliberately adopted 'science' in its broadest sense in order to include natural, environmental, social, health, economic and engineering sciences; 'technical' refers to technology and engineering practice and implementation (UNISDR, 2009c). These approaches reflect the recognition of the complexity of multi-hazard disasters across spatial and temporal scales through acknowledging the requirement for an interdisciplinary approach. This approach requires the full integration of natural, socio-economic, health and engineering sciences in excellence in disciplines and through the activities across disciplines (ICSU, 2008; Darnell, 2009). Furthermore, scientists themselves are more conscious of their role in providing informed assessments of risk to enable decision-makers to substantially reduce the impacts of disasters (e.g. Hill et al., 2013); however this science needs to be made accessible (Mercer, 2012).

Scientific (outsider) knowledge has been known to bring strategies that are detrimental to communities at risk or damaging to community knowledge; likewise, some local knowledge can be inappropriate and may actually increase vulnerability (Mercer, 2012). However, in integrating these knowledge types Mercer (2012) emphasises that it is not 'whose knowledge counts' but 'what knowledge counts' in order to develop 'hybrid' knowledge in DRR. Whilst DRR arguably requires the collaboration of a multitude of diverse experts, the disciplines within which these experts reside have cultivated their own understanding and terminology of disaster terms and this has led to misunderstandings (Twigg, 2007; Mercer et al., 2010). Thus, the process of integration requires parity and a mutual understanding of the cultural, material and epistemological essence of both science and community-based knowledge (Agrawal, 1995). Such recognition requires a brief overview of some of the key debates within the sociological approach to the public understanding of science.

**Sociological perspectives of science**

The thesis focuses on knowledge transfer in the context of multi-hazard assessments rather than the sociological analysis of public understanding of science. This latter approach addresses concerns beyond the communication of science, including why people cannot utilise scientific information even when they possess it. Whilst this sociological perspective is beyond the extent of this research and is largely framed from studies in developed countries, it is important to briefly review since it relates to the integration of science debate.

A number of studies have assumed that scepticism toward science is owing to a lack of understanding or knowledge or science, termed the 'deficit model' (Sturgis and Allum, 2004). The implication is that greater public understanding will lead to greater public acceptance of science and a more welcoming public climate for scientific and technological developments (Irwin and Michael, 2003). The deficit model has been criticised for oversimplification and disregarding the important contextual factors that influence people's attitudes towards science (Ziman, 1991; Irwin and Michael, 2003; Sturgis and Allum, 2004), including their pre-existing knowledge and information networks (Irwin et al. 1996). For instance, having more knowledge can also increase awareness of the associated uncertainties within science and, consequently result in less support for, or confidence in, science (Irwin and Michael, 2003). Furthermore, it may not be public ignorance but rather a lack of opportunity or trust in the body presenting the information that has led to less acceptance and utility of science (see Irwin and Michael, 2003). The problem may also be related to cognitive influences. From an interview analysis of laypeople in Lancaster, Irwin and Michael (2003) note three 'discourses of ignorance' including mental constitution ('[I] do not have a scientific mind'), division of labour ('it's not my job') and deliberate choice ('[I] don't know' and 'don't want to know'; see Irwin and Michael, 2003: 28). In the case of the deliberative choice, scientific knowledge is consciously ignored or avoided because it is perceived as essentially peripheral to or a distraction from the public's main concerns (Irwin and Michael, 2003). People may worry about risks according to the norms of their social context rather than reacting to allegedly more 'objective' hazards (Sturgis and Allum, 2004). Consequently, it is the scientific experts who are perceived as 'ignorant' since they are seen as opposed to the views of the layperson (Irwin and Michael, 2003).

Irwin and Michael (2003) argue that emphasis should not be on the public understanding of science *per se* but instead on the cultural conditions in which trust and identity shape the relationships between science and public. Understanding science relates to experience, judgement and understanding of science's institutional forms as much as its cognitive contents (Wynne, 1996).

In spite of the points raised above, Sturgis and Allum (2004) argue that the deficit model should not be totally rejected. Culture, economic factors (e.g. poverty), social and political values, trust, risk perception and worldviews are all influential in shaping the public's attitude towards science; but scientific knowledge may also have an additional and independent effect, for reasons not immediately understood (Sturgis and Alllum, 2004).

Sociologists maintain that the theory of risk society requires a constructivist interpretation of scientific knowledge and expertise (Fischer, 2000). Irwin et al. (1996) found that science has no special status in everyday life amongst the public and that it has to compete with other types of 'local' knowledge and understanding. Professional bodies have been criticised for being elitist and undemocratic (Irwin and Michael, 2003) and it has been argued that science is laden with social value judgements hidden within the steps and phases of the research process (Yearley, 2005).

Sociologists contend that it is difficult to separate facts from values and some have suggested that the public may not simply express values about the world but may also have knowledge of its own to offer – lay understanding and citizen science (Irwin, 1995; Wynne, 1996). Indeed, the citizenry is increasingly recognised by sociologists as being 'more intelligent' than many opinion researchers suggest (Fischer, 2000: 36). Furthermore there is an argument that (especially policy) experts need citizens (as much as citizens need experts) more than their professional ideologies have acknowledged (Fischer, 2000). The recent emphasis on community knowledge within DRR is acknowledging these respective needs (see Southgate et al., 2013).

Mercer et al. (2010) adopt an 'action research' based approach to the integration of science and community knowledge, suggesting that the researcher should facilitate the process of risk assessment in terms of guiding rather than teaching. Through the process, facilitators become experts in how people learn, clarify and decide for themselves (Fischer, 2000). Failure of citizens to participate in decision-making is frequently a manifestation of institutional processes that either hinder it or render it meaningless (Fischer, 2000). As such, scientists must be willing to engage with alternative worldviews and knowledge, rather than perceiving them to be ignorant or emotive (Irwin et al., 1996). This model of working underpins NGO approaches to participatory to community-based assessments of disaster risk (McCall and Peters-Guarin, 2012), which is the level at which hazard, vulnerability and capacity tends to be assessed.

### 2.3.4 Participatory approaches to hazard assessments

There is a notable absence of review of the hazard assessments implemented by NGOs. Here, the approach to community-based hazard, vulnerability and capacity assessments is introduced to provide context to the research that follows.

Humanitarian and development NGOs work at grassroots levels with communities and local organisations as partners, and use participatory approaches to assist communities to identify the risks they face, their development priorities and foremost to build local capacity (Benson et al., 2001; UNISDR, 2006). In 2001, a study of 22 humanitarian and development NGOs indicated that a stumbling block to the incorporation of hazard risk in planning was a lack of practical guidance (Benson et al., 2001). As a consequence, NGOs gradually began to develop methods – known as 'tools' or 'toolkits' – for participatory hazard, vulnerability and risk assessment. Toolkits consist of a set of instructions, checklists, guidelines and case studies outlining how to conduct what is usually a participatory analysis of hazard, vulnerability and capacity assessment (PHVCA). Participatory methods rely on the assumption that, even in the absence of sophisticated assessments tools, local communities can collect and share information on hazards (UNISDR, 2004). The techniques employed draw from approaches used in participatory rural appraisal (PRA) and rapid rural appraisal (RRA) that are discussed by Chambers (1997) and also incorporate the essence of the capabilities and vulnerability analysis (CVA) designed by Anderson and Woodrow (1998). CVA provides a method to assess the disaster situation and identify priorities for action (Heijmans and Victoria, 2001), as it questions any efforts to return to 'normalcy'. Normalcy constitutes the contributing vulnerabilities to the present and possible future disasters (Anderson and Woodrow, 1998; Bankoff and Hilhorst, 2009). CVA also highlights to relief workers how their interventions may unintentionally contribute to future vulnerabilities (Anderson and Woodrow, 1998).

During the 1990s, the pressure and release model (Wisner et al., 2004) and DFID's sustainable livelihoods approach (Carney, 1998) also emerged from a growing awareness of the need to incorporate hazard risks within a broader analysis of the underlying causes of vulnerability. As such, CVA techniques have subsequently been adapted by NGOs to aid their analysis of hazards, vulnerabilities and capacities of local people. These have then been further adjusted in order to include climate change, with revised and new toolkits emerging, developed specifically for CCA at the community level. A number of organisations have developed tools for PHVCA with nuances in naming conventions – notably most omit 'hazard' from the title. The processes adopted are highly qualitative and there appears to be a lack of probabilistic approaches to hazard and risk assessment. Some toolkits do determine risk through the combination of likelihood of impact and significance of impact, but these are still utilising qualitative approaches (e.g. Wiggens and Wiggens, 2009). Twigg (2004) notes that in practice, the difference between hazard, vulnerability and risk analysis is often blurred; hence there tends to be a lot of overlap. Risk analysis is, however, arguably broader, pertaining more to the interpretation of hazard, vulnerability and capacity data in order to make decisions regarding suitable interventions (Twigg, 2004).

Vulnerability is generally perceived to be the more complex measure to assess (e.g. Benson and Twigg, 2004; Twigg, 2004; Chiwaka and Yates, 2005) and there is concern that interventions initiated through community participatory techniques have a tendency to focus on the hazard rather than address the underlying vulnerabilities (Mercer et al., 2009). However, it is imperative to ensure that project planners and managers understand the characteristics of the hazard and its impact as part of a broader ecosystem and environmental context (Twigg, 2004) – not by over emphasising hazard risk but in highlighting its relative importance within the vulnerability context (Benson and Twigg, 2004). Physical characteristics of hazards affect coping strategies and therefore need to be identified, as evidenced in the Philippines where a group of urban poor conceptualised flood 'manageability' as a combination of household and community responses to the intensity (depth) and the duration of inundation (example in McCall and Peters-Guarin, 2012: 782).

Some tools make reference to multiple hazards or threats (e.g. De Dios, 2002); however since most toolkits have apparently been created for a specific purpose (for example, DRR or CCA) the implication is that they focus on the types of hazards as defined by these concepts (see Section 2.1.3). Notably, however, almost all toolkits draw on similar participatory methods for vulnerability analysis. These include transects walks; mapping (physical and socio-economic); stories and oral histories; semi-structured interviews and focus group discussion; daily time charts and seasonal calendars; time lines illustrating trends and change; direct observations; problem trees and flow charts and Venn diagrams of institutional linkages (see IFRC/RCS, 2007). The process requires facilitation by the NGO or local partner organisations and/or trained community members, which necessitates balancing the views of the facilitator with those of community members. Anderson and Woodrow (1998) stress that the CVA method is not designed to be prescriptive, but instead to guide users through a process of diagnosis.

**Sources of information and knowledge**

Owing to the difficulty of accessing quantitative technical reports and data within developing countries, Twigg (2004) suggests that it is not always necessary to rely upon technology and outside expertise and suggests that visual surveys and local people's knowledge of hazards are often more accurate and extensive than outsiders appreciate. Nevertheless, Anderson and Woodrow (1998) and Chambers (1997) state that secondary sources of information should be utilised in conjunction with participatory techniques of assessment and analysis. However of the few reviews of PHVCA (e.g. ActionAid, 1999-2003; Betts-Symonds, 2003; van Aalst et al., 2008; British Red Cross, 2009; Ruiz, 2010) most make little or no reference to secondary data for assessment and where it is discussed it is purely in the context of climate science. Understanding of climate change effects is driven by advances in science; consequently, these often encompass the starting point for practical measures (Sperling and Szekely, 2005). Van Aalst et al. (2008) suggest that facilitators should be able to triangulate the information provided by communities with the observed or projected climate change for the region. However, owing to the different spatial and temporal scales of community based assessments and global/regional climate change projections, it is unclear how the two would be readily triangulated (Prabhakar et al., 2009; Christian Aid and Ewbank, 2010; Romieu et al., 2010). A failure to effectively communicate climate change uncertainty in a practical manner has created substantial challenges for practitioners (Birkmann and von Teichman, 2010).

Twigg (2004) suggests that in addition to secondary sources that contain contextual situation reports and information on hazards, interviews with key informants, who may even include hazard experts, should be conducted. Fundamental to the PHVCA process itself, but a point often overlooked (Twigg, 2004), is enabling action via community empowerment in order to increase their capacity to improve their own situation (van Aalst et al., 2008).

In terms of DRR, local level analysis is the standard approach; however national-level analyses are at times conducted, particularly by larger organisations (Twigg, 2004). Ruiz (2010) argues that applying hazard, vulnerability and capacity analysis at the national level focuses too heavily on organisational capacity rather than the process of community vulnerability analysis and is time and resource intensive. In developing countries, local communities frequently form the first line of defence in reducing vulnerability and increasing resilience; there is a broad acknowledgement of the capacities of local communities in dealing with a variety of threats on their own (Gaillard, 2010). Natural systems and hazards, however, manifest at scales often well beyond that of the community level (Lee and Jones, 2004; Greiving et al., 2006; Schmidt-Thome, 2006; see Woo, 1999). This may well lead to the scale of the hazard or risk not being sufficiently understood.

In order to understand the historical context of risk, NGOs undertake participatory assessments using a variety of techniques, which include the creation of seasonal calendars and timelines in order to map the change in hazards over time. Whilst these methods are useful, they may miss the low frequency high impact events owing to the fact that they may not have occurred within the memory of community residents (van Aalst, et al., 2008). Missing such events could be an issue as NGOs and their partners try to be anticipatory.

**Critique of toolkits**

There are very few systematic reviews of the tools developed by NGOs for participatory community-based hazard (and risk) assessments, although participatory processes have received scrutiny more generally (e.g. Cooke and Kothari, 2001). In the context of hazard assessment, some general pitfalls of the methods adopted include:

- that ‘findings’ are often more descriptive than analytical (Heijmans and Victoria, 2001; De Dios, 2002), and this of course makes it difficult to set priorities for intervention (Twigg, 2004);
- that projects tend to be designed towards specific hazards, running the risk of overlooking other significant hazards (Twigg, 2004);
- by emphasising the socio-economic vulnerability, there is a prospect that risk more directly related to hazards may be overlooked (Benson and Twigg, 2004);
- the results are not standardised since the methods used and data collected vary according to time and place, thus it can be difficult to compare findings (Twigg, 2004; e.g. van Aalst et al., 2008).

However, the advantages of participatory community assessments are deemed to outweigh the limitations, as they provide a more detailed analysis and understanding of the communities’ situation whilst also identifying their capacity to deal with the circumstances (Twigg, 2004). Furthermore, the PHVCA process encompasses more than just a method for assessing hazard, vulnerability and capacity; it also emphasises community solidarity and empowerment, gender issues, power dynamics and project ownership by the community (see Twigg and Bottomley, 2011). The emphasis on taking action is, however, potentially outweighing the importance of underpinning decisions with rigorous analysis of the risk itself. In their inter-agency review of DRR, Twigg and Bottomley (2011) describe how agencies struggle to address all threats since the adoption of a holistic perspective to the disaster/vulnerability problem gives rise to the implication that NGOs are in the ‘impossible’ position of being able to deal with the array of problems that emerge. A key consideration in the assessment of hazards is, thus, prioritisation, which requires an initial assessment of the full range of risks (Twigg, 2004), however, van Aalst et al.’s (2008) review of climate change community risk assessments highlights a tendency to focus on recent, large disasters rather than the entire spectrum of hazard possibilities prioritised by likelihood and possible impacts.

Moreover, it is unclear whether the toolkits allow for the identification of hazard interrelations.

## 2.4 Summary: multi-hazard concepts and assessments

The review of the literature has emphasised some key concerns with regard to the concept of multi-hazards and their assessment across the humanitarian and development sector and hazard science. These concerns are summarised here.

A multi-hazard approach is the recognised basis for DRR. The humanitarian and development sector has, however, a tendency to compartmentalise risk into either DRR or CCA, which have inherent assumptions regarding the types of hazards and the spatial and temporal scale over which risk has to be considered. Adopting a multi-hazard approach might offer an opportunity for greater integration across these communities of practice. However, what constitutes a multi-hazard approach has received little attention beyond the field of hazard science.

Within this thesis, multi-hazard is conceptually framed as comprising both more than one hazard in a given place and the interrelations between hazards. These interrelations are categorised as amplification, association, causation and coincidence. However, the implementation of multi-hazard assessments has tended to focus on the analysis of more than one hazard, rather than the interrelations between hazards. Referring especially to NGO community-based hazard assessments, the choice of knowledge and the limited temporal and spatial scale of assessments are possible constraints on the extent to which multi-hazards are being assessed. The scope of identified hazards may also be constrained by the choice of a CCA or DRR approach, owing to the assumptions outlined above. Further investigation is required to fully determine whether the methods adopted are capturing the full range of hazards and their interrelations.

The literature review has demonstrated that both community-based and scientific knowledge and approaches should be integrated for more effective DRR, particularly in the context of multi-hazard assessment. Science is required to understand and quantify the complexity of multi-hazards, but the extent to which it is being utilised by NGOs for the purpose of hazard assessment appears to be fairly limited. However, owing to the lack of comprehensive reviews of hazard assessments, a key next step is to determine more specifically how NGOs assess multi-hazards and whether they utilise science in this context. The toolkits and processes NGOs utilise are not designed to be prescriptive (Anderson and Woodrow, 1998); as such, it is only by talking to those involved in developing and applying these that the process of implementing multi-hazard assessments can be determined.

The literature review has also identified a lack of guidance for NGOs regarding the requirements of a multi-hazard assessment, which is in part owing to the limited application of these assessments in hazard science. In order to address the shortfall in guidance, it is necessary to explore the reality of multi-hazards and their assessments by examining an actual case of multi-hazards. While assessments of 'all hazards in a given place' are imperfect, the focus of the case analysis is on the under-addressed area of hazard interrelations.

In order to address the above concerns, it is necessary to adopt a two-part approach to the subsequent analyses. Part one addresses current NGO approaches to hazard assessment, as it is necessary to first understand what NGOs are currently implementing and compare this with what is thus far understood about the requirement of a multi-hazard approach (i.e. the assessment of more than one hazard and the interrelations between hazards). Part two is a case study analysis of a multi-hazard disaster, with particularly emphasis on the interrelations between hazards, in order to refine the conceptual framework for multi-hazards and better understand the implementation of NGO and scientific approaches to multi-hazard assessment. The methodology adopted is discussed in the following chapter.

# Chapter 3: A two-part research strategy

Chapter 3 addresses the theoretical and practical aspects of data collection and analysis, emphasising why a largely qualitative approach to this research was adopted and justifying why semi-structured interviews, secondary data analysis, participant and field observations and informal meetings were regarded as suitable and complementary research methods. The research is divided into two parts; the first part explores current methods adopted by NGOs for the purpose of assessing multi-hazards. The second part builds on this initial analysis by examining a case study of a multi-hazard disaster in the Philippines, comparing it with the multi-hazard conceptual framework outlined in Chapter 2, particularly the interrelations between hazards, and examining the reality of multi-hazard assessments in this context. This case study is also used to explore methods and principles for assessing multi-hazards that incorporate scientific methods. The rationale for the chosen case study – the 2006 Typhoon Reming triggered lahars disaster – is specifically addressed in Chapter 6. Chapter 3 begins with an overview of the two-part research design, followed by an introduction to qualitative and mixed methods research and the validity of this approach and the details of the methods adopted. The chapter then outlines the design of the semi-structured interviews, the challenges of their implementation, critical reflexivity in social research and ethical considerations. The chapter concludes with a discussion of the techniques used to analyse the data.

## 3.1 Overview of research design

The research is divided into two parts; however these are can be subdivided into three distinct but complementary studies. Study A comprises interviews with (mainly) UK based Head Office NGO staff regarding their development and implementation of hazard assessment tools. Study

B comprises the same analysis but with NGO staff from the Philippines. Study C is the case study analysis of the Typhoon Reming lahars disaster and associated critical evaluation of scientific methods for assessing lahar in the context of multi-hazards. Figure 3.1 outlines how each of these studies was informed by the former and how the successive study helped to reinforce or challenge the findings of the previous study. Study A is largely exploratory, whereas Study B was conducted in order to test the developing theories from the results of Study A. Study C serves to compare the conceptual framing of multi-hazards from the literature review and is, therefore, informed by inferences made from the scoping study to the Philippines conducted during Study B, as well as the overall results from part one. Together the studies support a rigorous and triangulated approach to the research.

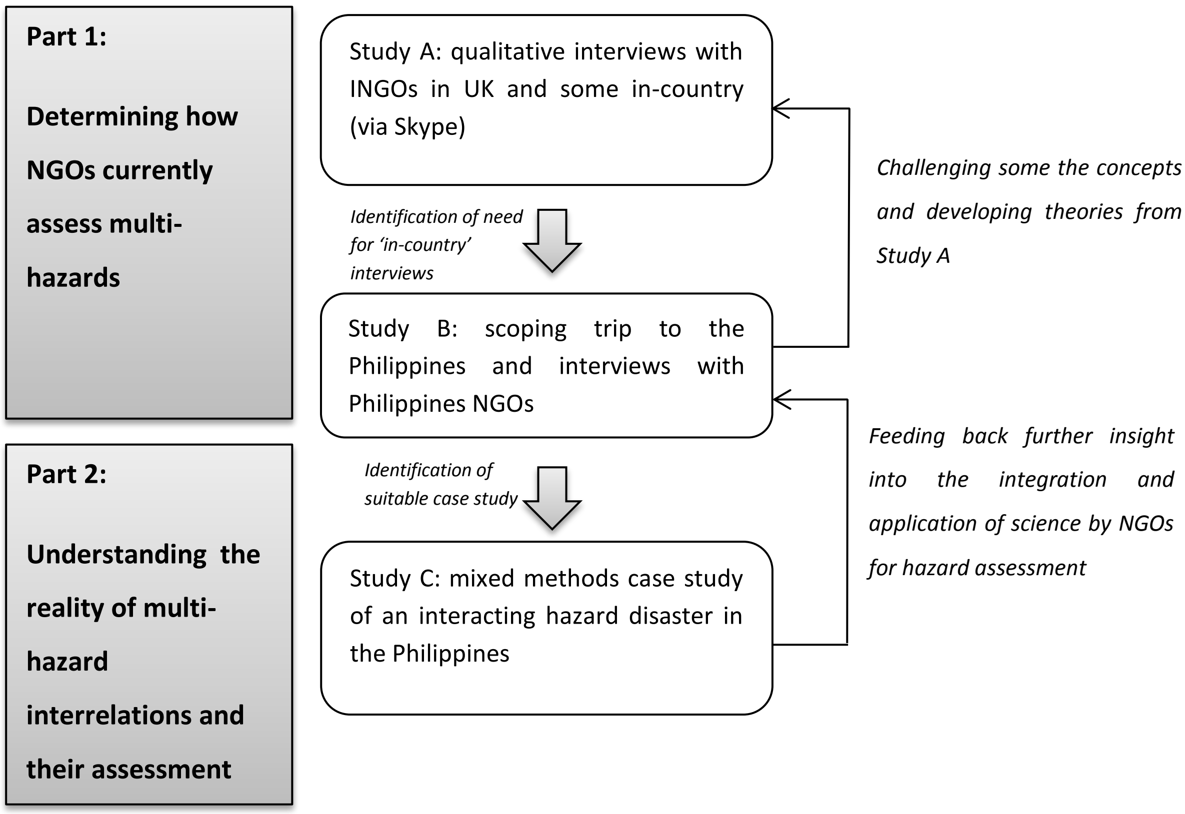


Figure 3.1 Conceptual framework for the research process.

## 3.2 Qualitative and mixed methods research

Maynoux (2006) suggests that the choice of research approach is based upon its purpose – in other words: what requires quantification and why – and that more information does not necessarily better yield a better result. Given the lack of critical analyses regarding the implementation of NGO multi-hazard assessments, the first part of this research is largely exploratory, thus lending itself well to the in depth, descriptive characteristics of qualitative research (Denzin and Lincoln, 2000), which are more likely to lead to serendipitous findings (Miles and Huberman, 1994).

In its broadest sense, qualitative study is focused upon observing, describing, interpreting and analysing the way that people experience, act on, or think about themselves and the world around them (Bazeley, 2007). Denzin and Lincoln (2000) state that:

> 'qualitative researchers stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry.' (2000:8)

A frequently cited distinction between quantitative and qualitative research is that the former tends to involve measurement whereas the latter does not; however, Bryman (2008) argues that such a superficial distinction does not capture the deeper differences. In social science research, both qualitative and quantitative researchers are concerned with the point of view of the individual (Denzin and Lincoln, 2000); however the epistemological and ontological positions of the different types of research tend to differ (Creswell, 2014; Table 3.1), but this distinction is not without contention (Bryman, 2008).

Table 3.1 The theory and philosophical differences between quantitative and qualitative research (however these are not mutually exclusive). Source: replication of table from Bryman (2008: 22, table 1.1).

| | Quantitative | Qualitative |
|---|---|---|
| ***Principle orientation to the role of theory in relation to research*** | Deductive; testing of theory | Inductive; generation of theory |
| ***Epistemological orientation*** | Natural science model, in particular positivism | Interpretivism |
| ***Ontological orientation*** | Objectivism | Constructionism |

Qualitative researchers take the position that reality and observations cannot be viewed from the epistemological position of positivism, which advocates the application of methods from the natural sciences to the study of social sciences (Bryman, 2008). Ontologically, positivists tend to claim that 'social entities can and should be considered objective entities that have a reality external to social actors' (Bryman, 2008: 18). A side step from positivism is critical realism, researchers of which acknowledge that 'we will only be able to understand – and so change – the social world if we identify the structures at work that generate those events and discourses' (Bhaskar, 1989: 2). In more direct opposition to positivism, qualitative research is often defined from the interpretivist perspective. Walsham (1993), in line with Bryman (2008), suggests that:

> Interpretative methods of research start from the position that our knowledge of reality, including the domain of human action, is a social construction by human actors and that this applies to researchers. Thus there is no objective reality which can be discovered by researchers and replicated by others, in contrast to the assumptions of positivist science (1993: 5).

The meaning of interpretivism is contested (Guest et al., 2013) and the term is often used interchangeably with 'qualitative research' (Williams, 2000). Williams (2000) broadens the term interpretivism to not only concentrating on 'linguistic interpretation of actors' meanings' but to include observation techniques, 'which seek to make sense of actors' actions and language within their "natural" setting' (Williams, 2000: 210). As hinted at in the above definitions, the major ontological debate is whether social entities can and should be considered objective entities that have a reality external to social actors (objectivity) or whether they can and should be considered social constructions built up from the perceptions and actions of social actors (constructionism – also known as constructivism; Bryman, 2008).

Most writers have focused on positivism/post-positivism, critical realism and interpretivism in their discussions of epistemologies. Creswell (2014) suggests two other philosophies or 'world views': transformation and pragmatism. Transformation is concerned with political change and tends to include participatory action researchers and power and justice oriented researchers. Pragmatism is problem-centred and not committed to one system of philosophy and reality (Creswell, 2014). Advocates of pragmatism argue that the research approach is problem led and embraces whatever methods are most suited to the analysis of the problem (Creswell, 2014).

Creswell (2014) suggests that researchers should make explicit the larger philosophical ideas they espouse in order to explain why they chose qualitative, quantitative or mixed methods approach for their research. The difficulty for an interdisciplinary researcher is that this type of research does not fit well within discrete philosophies and methodologies as defined by social science research. Furthermore, writers are not in agreement as to which philosophies require consideration (e.g. compare Bryman, 2008, and Creswell, 2014) and the definitions of these philosophies are to some extent contested (Bryman, 2008). However, here the researcher attempts to make explicit her position and the approach of the research.

Given the aim of this research, the emphasis is upon (1) understanding perspectives from the subject and audience of this research (NGOs); (2) grounding abstract concepts regarding multi-hazards in reality; and (3) the practical application of this research. The core philosophy held by the researcher is that research must be applied; this is distinctive from action research which adopts a transformative worldview – applied research is arguably broader and pertains to many worldviews and methodologies. The researcher would argue that applied research is the driving philosophy behind the methodological choices and methods adopted, whilst acknowledging that the research also holds interpretivist and constructivist claims (valuing the interpretation and context of respondents) and is pragmatic, by choosing not to be constrained in methodological options.

Finally, whilst the research is primarily qualitative, the case study (part two) adopts a mixed methods approach, best described by Creswell's 'convergent parallel mixed methods' in the sense that 'the investigator typically collects both forms of data at roughly the same time and then integrates the information in the interpretation of the overall results' (2014: 15; see Chapter 8). However, it should be recognised that Creswell's discussions are in the context of mixed methods approaches for social science research and perhaps do not consider instances where natural science data requires analysis in the context of qualitatively derived information (as in Chapter 8). Indeed, the mixed methods literature tends to focus upon the combination of qualitative and quantitative research strategies under the umbrella of social science (see Bryman, 2008; Guest et al., 2013; Creswell, 2014), rather than the combination of social and natural science enquiry. The application of quantitative analysis within this research is solely with regard to natural hazard (specifically lahar and rainfall data) as part of exploring quantitative multi-hazard assessments. The analysis of the data employs statistical principles regarding sample size, data quality and representativeness and these are discussed alongside the interpretation of the data in Chapter 8. The role of research evaluation criteria with regard to qualitative research is scrutinised in the following section.

### 3.1.1 The role of validity and reliability in qualitative research

Qualitative research has long been criticised for being subjective, challenging to replicate and often difficult to make generalisations from (Denzin and Lincoln, 2000; Bryman, 2008). The challenge from social researchers is that positivist measures of appraising research do not readily apply to qualitative research.

Qualitative 'validity' is concerned with the accuracy of the findings, whilst qualitative 'reliability' assesses whether the researcher's approach is consistent across different researchers and different projects (Gibbs, 2007). These terms are often differentiated into internal and external measures (LeCompte and Goetz, 1982):

- *internal reliability*: whether members of the research team are in agreement about what they 'see and hear';
- *internal validity*: whether the observations correspond to the theoretical ideas developed;
- *external reliability*: the extent to which the study can be replicated;
- *external validity*: the extent to which the findings can be generalised across different settings.

External reliability is particularly difficult in social research owing to the fact that it is impossible to replicate the social setting and the circumstances of an initial study in the sense in which the term is usually adopted (LeCompte and Goetz, 1982). Probably the most readily discussed measure is that of external validity, owing to the tendency to employ case studies and small samples in qualitative research (LeCompte and Goetz, 1982). Most qualitative case studies do not rely upon the use of statistics, therefore research design should involve the anticipation and enumeration of the important rival explanations for what is interpreted from the case study (Yin, 2009).

Given the problems in applying these terms to qualitative research, Lincoln and Guba (1985) present alternative criteria for evaluation, arguing that validity and reliability are quantitative research evaluation criteria and therefore do not lend well to the evaluation of qualitative research. Instead, they suggest the criteria of trustworthiness and authenticity. A comparison of the measures of trustworthiness is made against the concepts of reliability and validity outlined by LeCompte and Goetz (1982) in Table 3.2. Authenticity raises issues regarding the political impact of the research, for example whether the research fairly represents the views of the participants (Bryman, 2008). Criteria include ontological authenticity, educative authenticity, catalytic authenticity and tactical authenticity, which highlight how authenticity has affinity with action research, for example through empowering participants to engage in action (tactical authenticity; see Bryman, 2008).

Table 3.2 A comparison of Lincoln and Guba's (1985) criteria for evaluating research methods with LeCompte and Goetz's (1982) measures of validity and rigour. Source of information: Bryman (2008)

| **Lincoln and Guba's (1994) research evaluation criteria** | **Example of tools** | **Corresponding quantitative evaluation criteria** |
|---|---|---|
| Credibility: *ensuring the research is carried out according to the canons of good practice and submitting research findings to members of the social world who were studied for confirmation.* | Respondent validation<br>Triangulation | Internal validity |
| Transferability: *thick descriptions – these provide others with a database for making judgements about possible transferability of findings to other milieu.* | Rich descriptions | External validity |
| Dependability: *ensuring that complete records are kept of all phases of the research process.* | Auditing (however not readily utilised owing to the demanding time involved) | Reliability |
| Confirmability: *whilst recognising that complete objectivity is impossible in social research, the researcher can be shown to have acted in good faith.* | Reflexivity | Objectivity |

The criteria for evaluating qualitative research are contested, with researchers in disagreement regarding which is best to use, and a number of writers suggesting alternative methods (Bryman, 2008). Of particular relevance to this research is Hammersley (1992)'s reformulation of validity through his position midway between quantitative and qualitative research criteria. From a subtle realism position, he suggests that relevance is an important criterion of qualitative research, discussing whether the interests of the practitioner, who are defined as those who are part of the social setting being investigated and who have a vested interest in the research and its findings, might be considered (see Bryman, 2008). Clearly this practitioner focus is of relevance to the evaluation of this research, given the partnership with CAFOD.

Although contested, the above discussion highlights certain standards against which qualitative research might be evaluated. Qualitative researchers have been criticised for lack of transparency in terms of evaluating their research (Bryman, 2008). The reporting of this research has, therefore, endeavoured to embrace the need for transparency by emphasising where data is limited, the challenges that were faced and the limitations of this research.

## 3.3 Methodology and methods

Methodology is defined as 'a theory of how inquiry should proceed' (Schwandt, 2007: 193) and tends to relate to the epistemological philosophies and assumptions about validity introduced above. However, it is important not to overstate the interconnections between epistemologically and research practice since they represent tendencies rather than hardened rules (Bryman, 2008). What Bazeley (2007: 10) advises is that researchers are 'informed by methodology, but not a slave to it', which is the stance adopted here.

### 3.3.1 Grounded approach

The research concerns the process of multi-hazard assessment implementation by NGOs, their actions and the reality within which they made decisions to implement these processes, along with what is truly required by a multi-hazard approach to assessments. Being in a university-NGO partnership meant that the researcher had the opportunity to study and participate in the workings of NGOs; it was only by gaining an understanding of their reality and the context of their work that the research findings became meaningful. These findings are for the benefit of CAFOD and the NGO community. As such, the research is grounded in the perceptions of these participants, whilst also reliant upon their participation since NGOs comprise subjects, partners and end-users of the research.

Understanding a process in its reality pertains to grounded theory (Guest et al., 2013), which is an inductive data-led approach to building theory in a recursive and reflexive fashion (Hay, 2010). The process is inherently iterative in the sense that it employs a method of identifying themes or trends from data, collecting more data to refine the themes and repeating the process to build theory grounded in the 'real world' (Charmaz, 2006; Hay, 2010). Charmaz (2006) argues that grounded theory has both pragmatist and constructivist perspectives, which emphasises its applicability to the research:

> A pragmatist foundation can help you preserve an emphasis on language, meaning, and action in grounded theory…If you hold constructivist sensibilities, you may learn and interpret nuances of meaning and action while becoming increasingly aware of the interactive and emergent nature of your data and analyses (2006:184).

The background assumptions and disciplinary perspectives of grounded theorists' alert them to look for certain possibilities and processes in their data and give the researcher initial ideas to pursue and sensitise them to ask particular questions about their topic (Charmaz, 2006). Grounded theory as a methodological stance is contested, with some writers viewing it more as an approach to the generation of theory, through data analysis and interpretation (Bryman, 2008). For the purpose of this research, elements of a grounded theory approach to data analysis were adopted (see Section 3.7).

The research does not attempt the full extent of a grounded theory approach; there is less concern with the generation of theory and more with the exploration of the research question in an inductive manner. Elements of a grounded approach are adopted, for example no pre-set sample size (Guest et al., 2013) and the fact that the analysis of Study A was used to identify the need for more data and consequently Study B was implemented (*cf.* Charmaz, 2006). However, the research does not involve the in-depth, unstructured interview approach that characterises grounded theory and is, to some extent, pre-defined by literature. Furthermore, the majority of data was analysed after (and not during) the data collection (*cf.* Charmaz, 2006). Arguably the approach is 'grounded' in data rather than embracing the true extent of a grounded theory approach (Bryman, 2008). In contrast to the first part of the research, the second part is concerned with 'the in-depth analysis of a case' (Creswell, 2014: 14), which is discussed in the following section.

### 3.3.2 Rationale for a case study approach to critiquing multi-hazards

In the literature, different authors refer to case study as a method, methodology or a philosophy and not always consistently (Hammersley and Gomm, 2000; Simons, 2009). Frequently, definitions of case studies merely repeat the topics to which the case study has been applied (Yin, 2009). In general, however, it is agreed that a qualitative case study is a research approach that facilitates exploration of a phenomenon within its context using a variety of sources of data (Yin, 2009; Guest et al., 2013). Case study enquiry allows for the situation in which there will be many variables of interest and therefore it benefits from the prior development of theoretical propositions to guide data collection and analysis (Yin, 2009). This methodology therefore provides the opportunity to explore the conceptual framework of multi-hazards framed in the literature and how they might be assessed, utilising a triangulation of different sources of data.

As noted by Bryman (2008), there is a tendency to associate case studies with purely qualitative research, when in fact they lend themselves to both qualitative and quantitative lines of enquiry (Flyvbjerg, 2006; Simons, 2009; Yin, 2009). Yin (2009) distinguishes case study research from ethnography and grounded theory owing to the role of theory development prior to the conduct of any research – implying a deductive approach. Both the literature and the results of part one of the research help to determine theories regarding the concept of multi-hazards and NGOs capacity to assess these. However, beyond this doctoral research, the existing knowledge base regarding these phenomena (in particular NGO assessments of multi-hazards) is limited.

Opinions differ as to what constitutes a case. Stake (1995) argues that it relates to a specific unit, for example a person or location, whereas others are more open to including processes, policies and events (Simons, 2009). Stake (1995) distinguishes between intrinsic cases (interest in the case) and instrumental cases (gaining insight into a particular research question by studying a particular case) the latter being more applicable to this research. Yin (2003) develops the different cases further, by differentiating between five different types of cases:

- *critical case*: testing a well-formulated theory;
- *extreme or unique case*: specific case may be so rare that any single case is worth documenting and analysing;
- *representative or typical case*: the objective is to capture the circumstances and conditions of an everyday or commonplace situation;
- *revelatory case*: the opportunity to observe and analyse a phenomenon previously inaccessible to social science inquiry;
- *longitudinal case*: studying the same single case at two or more different points in time.

For the purpose of this research, the case study of the 2006 Typhoon Reming triggered lahars (introduced in Chapter 6) was selected on the basis of the scoping study to the Philippines. The aim was to identify a case that elucidated the reality of multi-hazard analysis, arguably (in this context) the 'representative or typical case.' At the same time, however, the case selected is situated within one of the most progressive DRR provinces in the Philippines (Albay), which is not only unique to the Philippines (see Chapter 6) but also in relation to many countries in which humanitarian and development actors operate. Whilst it may not be simple to situate this research within one of Yin's (2003) categories, it is important to have these categories in mind when analysing and discussing the results of the case study, especially in terms of explaining and generalising results and being aware of any potential bias.

**Making generalisations from a single case**

Many researchers harbour prejudices against the case study method, particularly owing to their concern over lack of rigour in case study research, evidenced by examples of case study research being deliberately altered to demonstrate a particular point more effectively (Yin, 2009). However, bias can creep into any research method (Flyvbjerg, 2006; Yin, 2009). In view of the criticisms and perceived limitations of a case study approach emanating from critics, Flyvbjerg (2006) has identified five common misunderstandings of case study research and instead highlights the value of such an approach (see Table 3.3).

These criticisms particularly relate to the generalisability of case studies and the perceived associated biases. Indeed, a pervading concern amongst critics is that case studies provide little basis for scientific generalisation (Flyvbjerg, 2006; Yin, 2009). Yin (2009) argues that case studies, like experiments, are generalisable to theoretical propositions and not to populations or universes. Bazeley (2007) observes that:

> it is not that we can describe the characteristics of a larger population, survey style, but rather that we gain understanding of the way some aspect of society works – an understanding of processes and principles, theory rather than facts (2007: 411).

It is by virtue of the above that Bazeley (2007) considers, with appropriate modifications to account for variations in context, such theory might then be applied to a new setting within that society, or perhaps even more widely, for example a multi-hazard framework for a setting beyond the Philippines.

Table 3.3 Common misunderstandings of case study research and alternative points of view. Source of information: Flyvbjerg (2009).

| Misunderstanding | Alternative |
|---|---|
| ***(1) General, theoretical (context-independent) knowledge is more valuable than concrete, practical (context-dependent) knowledge.*** | Predictive theories and universals cannot be found in the study of human affairs. Concrete, context-dependent knowledge is, therefore, more valuable than the vain search for predictive theories and universals. |
| ***(2) One cannot generalise on the basis of a single case and that the case study cannot contribute to scientific development.*** | One can often generalise on the basis of a single case, and the case study may be central to scientific development via generalisation as supplement or alternative to other methods. But no formal generalisation is overvalued as a source of scientific development, whereas "the force of example" is underestimated. |
| ***(3) The case study is most useful for generating hypotheses; that is, in the first stage of a total research process, whereas other methods are more suitable for hypothesis testing and theory building.*** | The case study is useful for both generating and testing of hypotheses but is not limited to these research activities alone. |
| ***(4) The case study contains a bias toward verification, that is, a tendency to confirm the researcher's preconceived studies.*** | The case study contains no greater bias toward verification of the researcher's preconceived notions than other methods of inquiry. On the contrary, experience indicates that the case study contains a greater bias towards falsification of preconceived notions than toward verification. |
| ***(5) It is often difficult to summarise specific case studies into general propositions and theories.*** | It is correct that summarising case studies is often difficult, especially as concerns case process. It is less correct as regards case outcomes. The problems in summarising case studies, however, are due more often to the properties of the reality studied than to the case study as a research method. Often it is not desirable to summarise and generalise case studies. Good studies should read as narratives in their entirety. |

Whilst, qualitative researchers may claim to adopt a generalisation free approach to their data interpretation, Williams (2000) states that generalisation is 'inevitable, desirable and possible' in interpretivism. Additionally, Stake notes that seldom is 'case-by-case uniqueness' a component of scientific theory (2000: 439). It is therefore necessary for the researcher to be conscious of the tendency to generalise, aiming for analytic generalisation (expansion and generalisation of theories) and not statistical generalisation (enumeration of frequencies; Yin, 2009). At the same time, it is necessary to avoid the danger of overly focusing on generalisation at the expense of understanding the details of the case itself (Stake, 2000).

Case study researchers encounter circumstances to generalise by drawing on observations from comparable cases investigated by others (Williams, 2000). In addition, combined with the findings from part one of the research, this case can provide informative results for shaping future NGO approaches to hazard assessment more generally.

Bazeley (2007) suggests that methods are directed but not prescribed by a particular philosophical or methodological view. For example, Charmaz (2006) states that grounded strategies can be used with a variety of data collection methods and that she treats these methods as 'tools to use rather than as recipes to follow' (2006: 28). Case study research also lends itself to a number of methods, both qualitative and quantitative. The following section outlines methods used in both parts of the research, but the specific implementation of methods and the data collected for part two are outlined in Chapter 6. A discussion of the research evaluation criteria applicable to these methods then follows.

### 3.3.3 Multi-method research approach

Given the interdisciplinary nature of the research, no single method was sufficient for data collection. Consequently, the decision was made to adopt a mixture of four different methods: semi-structured interviews, informal meetings, observations and secondary data analysis. The selected methods and the justification for each are outlined below, followed by the means of evaluating the rigour and quality of the research applied.

**Semi-structured interviews**

The most obvious means of understanding how NGOs conduct multi-hazard assessments is by collecting the experiences and views of those who develop and implement these methods themselves. Essentially, interviewing is a conversation, albeit one manufactured for research ends (Dowling, 2010), and can range from structured inflexible formats to fully unstructured in-depth discussion. Where the researcher positions herself on this spectrum relates to both the objective of the research as well as the practicalities of implementation. Given the lack of prior reviews of NGO tools for hazard assessment, and having regard to the formulation of some ideas regarding the approaches NGOs adopt from the literature analysis, the most appropriate approach to interviewing was semi-structured. This type of interview allows for a balance between gathering data on topics the researcher is interested in (e.g. knowledge and scale of application), whilst also allowing unanticipated information to emerge.

Semi-structured interviews are a means of exploring the perceptions and views of respondents by probing for more information and clarification of answers (Barriball and While, 1994). This method is therefore a powerful means of conducting exploratory research, as its flexibility allows for unanticipated avenues of enquiry to be pursued should they emerge during the conversation (Valentine, 2005). Semi-structured interviews were also deemed appropriate for part two of the research since they comprise a means of documenting the opinions of a diverse sample group (Barriball and While, 1994). This latter data collection and analysis necessitated meeting with interviewees ranging from government scientists to local communities.

The challenge of interview based research is in managing its labour intensive implementation and data analysis demands. There are numerous opportunities for bias to emerge since interviews are couched within the experiences and subjectivity of the interviewee and the influence and positionality of the researcher (Valentine, 2005). Unless they can be repeated, interviews represent a snap shot in time and may reflect the mood and level of engagement of the participant and interviewer at that moment. In order to minimise bias, questions are carefully constructed and phrased and, where possible, more than one perspective from the same organisation included. The researcher should adopt a reflexive stance, by acknowledging where she might have influenced the interview process and data analysis and how her position and perception in the eyes of the participant may have influenced their choice of answer (see Section 3.5).

In the context of the case study, there is also the question of the veracity of the eye witness accounts of those interviewed about the Typhoon Reming lahar disaster (Guthrie et al., 2009), especially in the case of accurately reciting a disaster that occurred six years prior. However, this can be minimised through data triangulation. The implementation challenges and ethical considerations when conducting this type of research are explored in later sections.

Semi-structured interviews employ an interview guide, which can (and did) include fully worded questions that the researcher is not restricted to asking. Furthermore, the interview is organised but questions need not be followed in a sequential manner (Bryman, 2008; Dunn, 2010; Newing, 2011). The challenge of semi-structured interviewing lies with the interviewer; they have to balance the skill of allowing emergent topics to transcend, whilst at the same time ensuring the interviewee focuses upon the topic at hand (Dunn, 2010).

Semi-structured interviews were adopted as a primary means of gathering data for both components of the research. The details of their design, sampling strategy and implementation are discussed in Section 3.4.

**Informal meetings**

The opportunity for informal meetings arose both in the UK and the Philippines. These meetings provided an additional opportunity to (1) understand the NGO sector and multi-hazards as well as (2) determine the key actors in the field of multi-hazard assessments in the Philippines. In the UK, informal meetings were conducted with:

- DRR and CCA representatives from the UK Department for International Development: four meetings over the course of the research to discuss multi-hazards, DRR and CCA;

- two representatives of International Institute for Environment Development (IIED): met to discuss community-based CCA, multi-hazards, the utility of science and the Philippines;
- a representative of the Emergency Capacity Building Project: discussed NGO toolkits over a Skype meeting;
- a representative of the international NGO Acción Contra el Hambre: discussed their work in the Philippines over a Skype meeting.

A number of informal meetings were also conducted during the scoping visit to the Philippines (September 2010) in order to help the researcher understand the DRR and multi-hazard context of the Philippines, as well as identify a possible case study for the final component of the research (see Table 3.4). Some of the information from these is directly referred to within the presentation of results in chapters 5 and 9, but the majority is acknowledged as having played a role in informing the researcher as to the wider context of her research.

Table 3.4 Informal meetings in the Philippines.

| ***Type of participant*** | ***Number of participants*** | ***Location*** | ***Details*** |
|---|---|---|---|
| *Local NGOs* | 4 | Manila and Legazpi City (Albay) | 3 humanitarian/ development; 1 conservation |
| *International NGO* | 1 | Manila | Humanitarian/Development |
| *Donor* | 1 | Manila | Asian Development Bank |
| *Scientists* | 8 | Manila | 5 government (PHIVOLCS, MGB, NAMRIA, PAGASA); 1 not for profit; 2 academic (Geologist and Hydrologist) |
| *Local government* | 3 | Legazpi City (Albay) | Emergency managers |
| **Total** | **17** | - | - |

Informal meetings were unrecorded and did not always involve the signing of the consent forms, as this was deemed inappropriate in the Philippines and instilled a sense of formality in what was an informal setting built on verbal understanding and trust between the participant and interviewer. Participants were fully aware that they were meeting to discuss topics for the research project.

**Secondary data and information**

During both studies, a key component of the research was the collection and analysis of documentation relating to (1) the NGOs interviewed and their existing toolkits for hazard assessment and (2) literature and internal reports on the case study, along with historical records of previous disasters, lahar occurrence and quantitative rainfall data. The data collected for the case study analysis are further described in Chapter 6.

For the purposes of part one of the research, prior to and during the interviews, documentation detailing the background to the organisations being interviewed was collected, which helped to contextualise the answers from different organisations. Specific details regarding these cannot be shared since they would compromise the anonymity of the interviewees but they included:

- annual reports
- programme summaries and reviews
- toolkits

The respective organisations' toolkits for conducting participatory community-based (hazard), vulnerability and capacity assessments for the purpose of DRR and/or CCA were reviewed in order to tailor specific questions to ask of interviewees. In addition, toolkits for conducting participatory community-based hazard, vulnerability and capacity assessments for DRR or CCA were more broadly consulted, in order to identify at a more general level the extent of their adoption of a multi-hazard approach and inclusion of scientific as well as community knowledge. This study gave the researcher a prior understanding of these toolkits; and it was through this analysis that she recognised the need to speak with those actually involved in designing and implementing the process in order to fully understand these toolkits.

The challenge of collecting secondary data and information is that it relied upon the goodwill of the interviewees, who were often extremely busy and, therefore, not always able to send these to the researcher. However, when shared it was an invaluable means of providing context and triangulating the information collected during the interviews.

**Observation research: the importance of context and participation**

Kearns (2010) argues that ‘observation has been taken for granted as something that occurs ‘naturally’… [but that] with critical reflection observation can be transformed into a self-conscious, effective and ethically sound practice’ (2010: 241). In social science observation requires more than simply seeing – listening is a critical aspect of participant observation (Kearns, 2010).

The research makes no claims to adopting an ethnographic approach but opportunities for observational research comprised an important means of understanding the context of the other methods of data collection. Bazeley (2007) notes that awareness of context (e.g. through ‘naturalistic observation’) is one of the most often acknowledged characteristics of a qualitative approach to research. Irrespective of the primary mode of data collection, she states that observations ensure a balance of perspectives gained from participants (Bazeley, 2007). Qualitative observation involves the researcher taking notes on the behaviour and actions of individuals at the research site, essentially field notes, and can vary from non-participation to totally participation of the researcher (Creswell, 2014).

There were three main opportunities for participant observation during this research, and reflecting on these emphasises the need to be reflexive regarding how the researcher’s presence in these situations may have shaped and influenced the observations she made

(Valentine, 2005). The first opportunity was time spent at CAFOD, which would range from passive observation of the workings of an NGO (Kearns', 2010, 'observer-as-participant'), participation during meetings and workshops, giving of presentations and involvement in group discussions, to discussing concerns with individual staff on, for example, how to integrate science or hazard assessment in a particular project. The second opportunity was via external NGO/donor workshops, forums and trainings, which allowed the researcher insight into the context of DRR in the NGO sector. Lastly, observations were made in the Philippines at additional activities the researcher was invited to attend.

Observations are a useful means of contextualising the research and achieving insight into the bigger picture. However, there are ethical implications of recording observations of those perhaps not fully appreciative of why they are being observed. However, in the context of this research, most participants were aware of the researcher's position.

The details of the opportunities for observation are given in Appendix A. Opportunities for observations were by at times unforeseen (e.g. last minute invitation to attend NGO forums in the Philippines). Field notes were taken throughout the two visits to the Philippines, with the researcher compiling a daily account of her experiences and reflections of interviews, meetings and surroundings of the previous day. The research also required observations in the Philippines beyond that of participants in the study, for example observations of structural vulnerability and exposure to multi-hazards (see Chapter 6). A key means of documenting these was by taking photographs.

### 3.3.4 Research evaluation criteria

The following means are adopted in order to ensure rigour and quality of research in the context of the evaluation criteria outlined in Section 3.1.1.

- *Triangulation*: the two-part research design means that different studies and methods are brought together to answer the research question. In the context of the first part of the research, in-country agencies in the Philippines were interviewed in order to triangulate initial findings from the Head Office interviews (Study A). Furthermore, by including observations, informal meetings, document analysis and (in the case study) quantitative secondary data analysis in the research, the findings are triangulated by a number of sources. Lastly, the case study not only requires mixed methods in its approach but is also a means of building on the findings from part one of the research. In Chapter 9 the findings are compared with other studies and cases in order to support or refute the findings from this analysis.
- *Two field visits*: being in the fortunate position of being able to have both a scoping and subsequent visit to the Philippines helped to refine the researcher's understanding, interpretation and development of concepts, as well as meaning she was able to meet with some participants more than once.
- *Reflexivity*: this quality in a researcher is introduced in the discussions above and is explored in greater detail in Section 3.6.
- *Auditin*g: this methodology chapter, along with Chapter 6, provides a rich detail of the methodologies and methods pursed so that the process might be repeated, in as far as is possible in the context of qualitative research, by future researchers.
- *Research partner validation*: CAFOD are partners in this investigation, therefore a key component has been constant liaison and communication of research findings with the appointed representative at CAFOD. Ensuring the research is reviewed by a practitioner and end-user helps to ensure that it is grounded within the field of applied research.

The following discussions outline the design of the semi-structured interviews along with challenges in their implementation and the ethical implications of this method. This discussion is followed by overview of the methods adopted for data analysis.

## 3.4 Design of semi-structured interviews

Valentine suggests that 'hard and fast rules' of interviewing do not exist because each interviewee is an individual and therefore each interview will be different (2005: 119). However, for transparency it is necessary to outline the principles observed and choices made in this research.

The interview guide consisted of primary and secondary questions – the former to initiate discussions and the latter as prompts to encourage the informant to expand upon a point discussed (Dunn, 2010). However the style of interviewing was flexible enough that the interviewer often asked follow-up questions based on participants' responses. The questions were all open-ended, in other words the interviewer did not present the participant with a set of possible answers to choose from (McCracken, 1988; Bryman, 2008); however, she would supply prompts if the participant was struggling to answer.

The interview questions were specific to the three data collection activities that took place: (1) the interviews with INGOs that took place in the UK; (2) the interviews with INGO and local NGOs in the Philippines (September 2010); (3) the interviews with scientists, NGOs, government officials and local communities for the purpose of the case study analysis in the Philippines (October to November 2012). The topics discussed during each of the respective studies are outlined in Table 3.5 and Appendices B and C contains the interview guides for parts one (Studies A and B) and two of the research. The questions asked in Studies A and B were similar, save for the removal of the development of toolkits in Study B. In the case of this first part of the research, the topics were selected to encourage discussion regarding the design and implementation of community-based hazard assessments ('toolkits') from a number of different angles. Although semi-structured in their approach, certain questions were deliberately asked owing to prior interest and assumptions made by the researcher from reviewing the literature. The most notable example is questions regarding the inclusion of scientific information and knowledge in the process of hazard assessment. The finer details of the semi-structured interviews implemented during the case study are discussed in Section 3.4.2 and Chapter 6.

Table 3.5 Categories of enquiry in the semi-structured interviews

| ***Study A*** | ***Study B*** | ***Study C*** |
|---|---|---|
| 1. history of CCA/DRR in the organisation<br>2. adoption and/or development of toolkits<br>3. process of hazard assessment<br>4. evaluation of process and toolkit feedback<br>5. role of science in CCA/DRR | 1. history of CCA/DRR in the organisation<br>2. adoption of toolkits<br>3. process of hazard assessment (and decisions regarding where to work)<br>4. evaluation of process and toolkit feedback<br>5. role of science in CCA/DRR | 1. experience of the event<br>2. anticipation of the event<br>3. learning from the event<br>4. understanding of the event and perceptions of future risk |

Questions were largely a mixture of the following types of questions (see Valentine, 2005; Dunn, 2010):

- descriptive (background to participants)
- structured (e.g. development of toolkits)
- opinion (e.g. do you think science can help in DRR?)
- storytelling (e.g. history of DRR in the organisation and the story of the Typhoon Reming disaster)

During study A, the interview was piloted with the first NGO interviewed in order to determine whether the questions were fully understandable; only minor revisions to the interview guide were required after this. All interviews were designed to be conducted on a one-to-one basis, however in the Philippines interviews were at times conducted in pairs or groups.

### 3.4.1 Sampling strategy

Sites or individuals are generally purposefully selected for study in order to help the researcher understand the problem and the research question (Dunn, 2010; Creswell, 2014). However, consideration of sample size is less often discussed than other components of research design (Bryman, 2008; Robinson, 2014); therefore it is necessary to ensure that this component of research design is adequately addressed in this study. Robinson (2014) suggests four considerations with regard to sampling, which are detailed in Table 3.6 alongside their application to this research. The sampling strategy for parts one and two of the research are described in the following sections.

Table 3.6 Sample considerations for this research based upon the four considerations identified by Robinson (2014).

| ***Consideration*** | ***Approach*** | ***Application to part one*** | ***Application to part two*** |
|---|---|---|---|
| *Sample universe* | *Establish a sample universe, specifically by way of a set of inclusion and/or exclusion criteria.* | Those involved in the development and implementation of NGO tools for hazard assessment. | Scientists, DRR practitioners (local government and NGOs) and communities affected by Typhoon Reming lahars (over 18 years of age). |
| *Sample size* | *Choose a sample size or sample size range, taking into account what is ideal and what is practical.* | Balance between saturation and logistics; saturation criterion was on the basis that no new themes were emerging in subsequent interviews (Charmaz, 2006). | |
| *Sample strategy* | *Select a purposive sampling strategy to specify categories of person to be included in the sample.* | Snowball (chain sampling) | Majority of suitable participants identified during the scoping trip; this was also supported by a snowball (chain sampling). |
| *Source* | *Recruit participants from the target population.* | Targeting through a gatekeeper; contacts in Philippines through supervisors and initial interviewees. | Recruitment was through inviting participants identified during the scoping study as well as through gatekeepers who would invite communities to be interviewed. |

**Part one: Interviews with NGOs on hazard assessment methods (Studies A and B)**

The sample universe consisted of primarily humanitarian and development actors who had been involved in the design or implementation of NGO toolkits for assessing hazard in the context of DRR and/or CCA. Within this, there were two kinds of participant: international NGOs (both head office and in-country) and researchers/consultants (Table 3.7). The reason for seeking to interview in-country NGO staff was owing to the researcher's suspicion that interviewees at Head Office might be removed from the day-to-day activities in which the research is interested (Mercer, 2006).

In terms of sample size, the interviews were conducted upon a trade-off between saturation and practical constraints. A number of major organisations within the UK were included, but only a small number of 'in-country' representatives were interviewed, as establishing interviews with their operational staff proved difficult; organising these relied on the help of the Head Office interviewees, whose busy workload meant they were not always able to assist. The decision was therefore made to conduct a second study of in-country participants in person during a scoping visit to the Philippines (Study B; Table 3.8).

Table 3.7 Number of participants across each of the types of participants interviewed during Study A. The number of organisations represented in given in brackets.

| ***Type of participant*** | ***Number of participants*** | ***Type of organisation participant is from*** | | ***Current position*** | | |
|---|---|---|---|---|---|---|
| | | ***Humanitarian or development*** | ***Other*** | ***DRR*** | ***CCA*** | ***Both*** |
| *Head office NGOs* | 19 | 18 | 1 | 11 | 7 | 1 |
| *Field based NGOs* | 4 | 4 | 0 | 3 | 1 | 0 |
| *Other (researchers and consultants)* | 3 | 2 | 1 | 1 | 2 | 0 |
| ***Total*** | **26** | **24 (12)** | **2 (2)** | **15** | **10** | **1** |

Table 3.8 Number of participants across each of the types of participants interviewed during Study B. The number of organisations represented in given in brackets.

| ***Type of participant*** | ***Number of participants*** | ***Type of organisation participant is from*** | | ***Current position*** | | |
|---|---|---|---|---|---|---|
| | | ***Humanitarian or development*** | ***Other*** | ***DRR*** | ***CCA*** | ***Both*** |
| *Country office NGOs* | 4 | 4 | 0 | 4 | 0 | 0 |
| *Local NGOs* | 5 | 5 | 0 | 5 | 0 | 0 |
| **Total** | **9** | **9 (7)** | **0** | **9** | **0** | **0** |

There was unequal representation of each of the organisations interviewed (ranging from one to four participants per organisation); however, the aim was to understand the sector (rather than individual organisations) and the researcher felt that saturation was reached by the fact that towards the conclusion of the study fresh data gathering ceased to reveal new insight (Charmaz, 2006; Newing, 2011). All those interviewed are involved in DRR and/or CCA in their respective organisations, so it was assumed that their opinions were representative of the organisation (however the instances when these opinions were contested within interviewees' organisations are acknowledged during the presentation of the findings). Furthermore, this study encompassed only the first part of the research and not the research in its entirety, thus it was bound by practical constraints. The comparatively smaller number of interviews conducted in the Philippines reflects the time-frame for this activity (three weeks) and the dual purpose of the trip, part of which was to identify a suitable case study for the second part of the research.

Participants were recruited in the first instance by targeting INGOs through the assistance of a gatekeeper – 'an individual who has the power to grant access to people or situations for the purposes of research' (Burgess, 1984: 48). In this instance, the gatekeeper was an academic supervisor who had access to INGOs and could verify the legitimacy of the researcher to them. Through these initial interviews, the researcher was able to establish further interviews – a technique known as snowball or chain sampling (Valentine, 2005; Hay, 2010; Secor, 2010; Robinson, 2014). Such a strategy acknowledges the fact that the identification of possible participants may only become apparent during meetings and interviews with other participants.

**Part two: Case study interview sample (Study C)**

The criteria for interview sampling was any person who had either been affected by the typhoon (e.g. residents in the five most affected municipalities) or had been involved in planning for, or responding to, the event in the capacity of an NGO, scientist (academic, government or other) or local government. Those involved in the event from a professional stance are termed 'DRR stakeholders'. All but one participant was Filipino.

***Selection of DRR stakeholders***

The main strategy for sampling was the identification of key people from the information gathered during the 2010 scoping trip – meaning that some of those interviewed in 2012 were also interviewed in 2010. The representation from each of the scientific organisations is variable, with the Philippine Institute of Volcanology and Seismology (PHIVOLCS) representing the agency with the most scientists interviewed. This is in part attributable to the snowballing technique but more so owing to the relevance of this agency to a lahar case study and is, therefore, not deemed to create any additional bias. Table 3.9 summarises the participants interviewed and more detailed information about each of the participants is presented in Chapter 6. Of these participants, nine scientists, four representatives of local government and seven NGO staff were primarily interviewed about the case study. The additional scientist and NGO interviewees were less familiar with this disaster and so were instead asked about NGO applications of science in order to build on the findings from part one of the research.

Table 3.9 DRR stakeholders interviewed during the case study

| *Type of participant* | *Number of participants interviewed* | *Number of agencies represented* | *Location* |
|---|---|---|---|
| *Scientists (government)* | 10 | 3 | Manila and Albay |
| *Scientists (academic)* | 2 | 1 | Manila |
| *Government (local and regional)* | 4 | 3 | Albay |
| *International NGO* | 3 | 2 | Manila |
| *Local NGO* | 7 | 5 | Albay |
| **Total** | **26** | **14** | |

***Access to local communities***

In order to meet with communities, the strategy was to gain access via 'gatekeepers' (Mercer, 2006; Dunn, 2010; Creswell, 2014), in this instance local NGOs and local government. The researcher requested visits to the lahar affected municipalities of Guinobatan, Sua, Daraga and Santo Domingo, as well as the relocation Barangays Anislag (housing former residents of Barangay Tagas in Daraga) and Taysan (housing former residents of Barangay Padang, Legazpi). The selection of communities was dependent upon the gatekeeper's time and the availability of community members, which is reflected by the fact that some barangays were more represented than others (see Table 3.10). The only area where no visit could be arranged was Barangay Taysan. Barangay Padang was visited for the purpose of field observation not interview. See Figure 3.2 for the locations of barangays (communities) visited.

The criterion for interviewees was that they had been affected by the lahars in terms of impact to their home, livelihoods, valuables and/or family. The only demographic prerequisite of community participants was that they were over the age of 18, to comply with the ethical approval awarded by UCL. It so happened, however, that the majority of interviewees were women between the ages of 35 and 64 (Figure 3.3). This is mostly an artefact of culture: the interviews were conducted during the day, which coincided with when the men were at work; however it is not clear why this age range was predominant. The local NGOs appear to have channelled their work through women's groups (e.g. child nutrition group in Barangay Salvacion) resulting in their taking the researcher to meet with these groups.

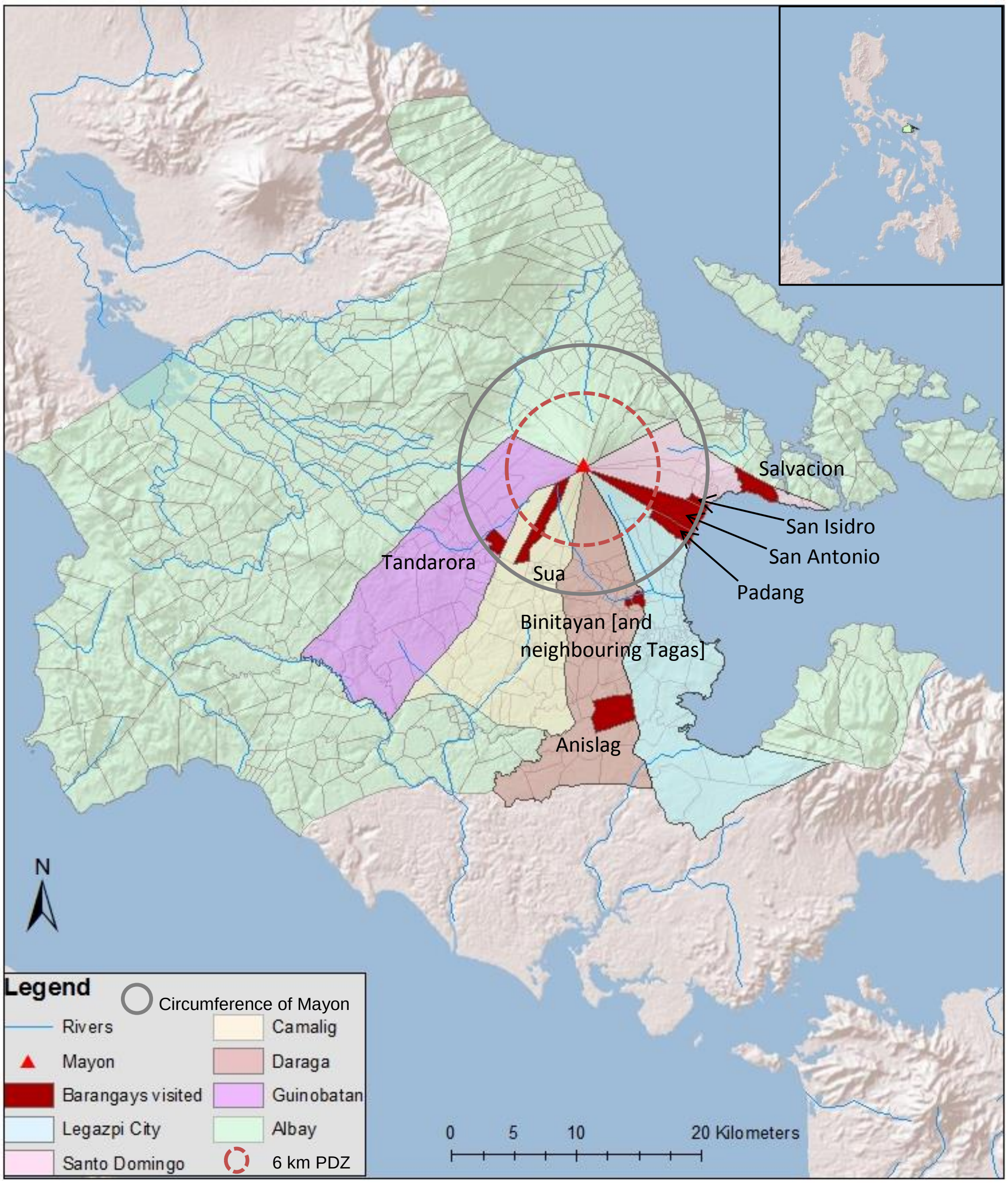


Figure 3.2 Location of the Municipalities, including Legazpi City, and the Barangays visited in October and November 2012. The grey circle represents the approximate circumference of Mayon volcano and the dashed red circle is the 6km radius permanent danger zone (PDZ). Source of data: Phil GIS (2013).

Table 3.10 Residents interviewed during the case study. Numbers in brackets reflect the number of people who predominately spoke as some of these interviewees involved groups of participants.

| ***Municipality*** | ***Barangay*** | ***Numbers interviewed*** | ***Percentage female*** | ***Percentage male*** |
|---|---|---|---|---|
| Camalig | Sua | 1 | 100% | 0% |
| *Daraga* | Binitayan | 12 (5) | 100% | 0% |
| | Anislag (Tagas) | 6 (3) | 100% | 0% |
| *Guinobatan* | Tandarora | 15 (9) | 93% (88%) | 7% (11%) |
| *Santo Domingo* | Lidong | 5 | 60% | 40% |
| | Salvacion | 4 | 100% | 0% |
| | San Antonio | 2 | 50% | 50% |
| | San Isidro | 1 | 0% | 100 % |
| **Total** | **All barangays** | **46 (30)** | **89% (83%)** | **11% (17%)** |

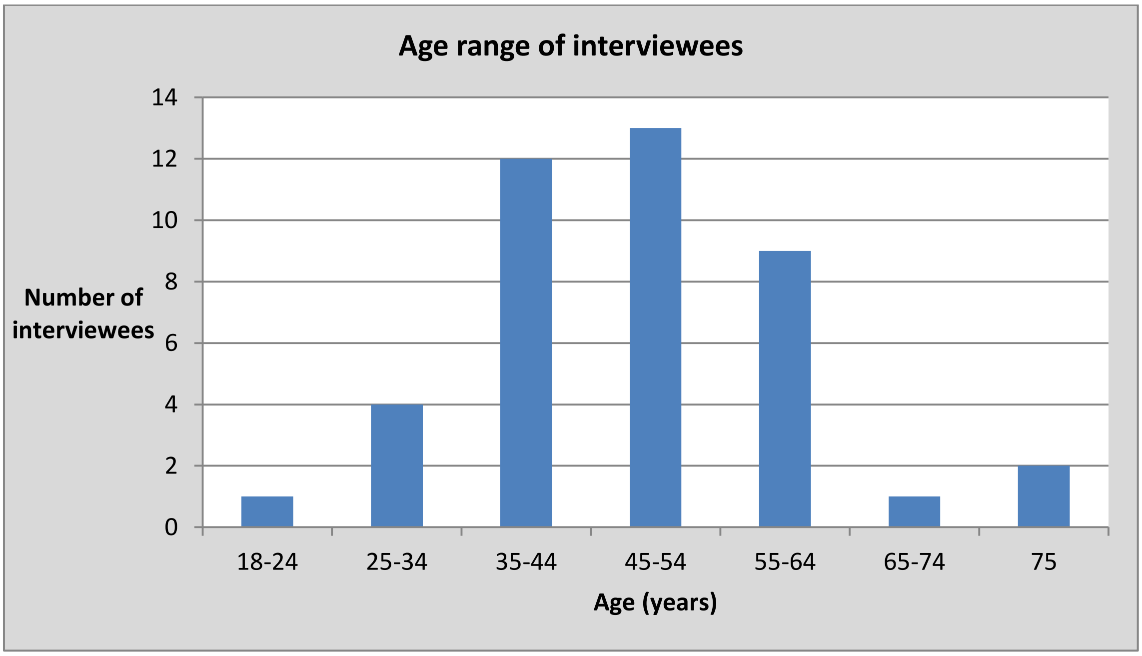


Figure 3.3 Age range of community interviewees.

There were numerous actors involved in and/or affected by the Typhoon Reming case study disaster who might have been interviewed. The reason for cessation of the study was that community members shared very similar stories of the events and that the means of accessing DRR stakeholders were exhausted within constraints of the project. The following discussion reflects upon the experiences of implementing the research, in particular the semi-structured interviews. Each study is addressed in turn.

### 3.4.2 Data collection: implementation, limitations and suggestions for future research

**Study A – interviews conducted in UK**

The interviews with NGOs were conducted between December 2009 and August 2011, but the majority occurred between December 2009 and August 2010. The aspiration was that all interviews be conducted face to face; but five interviews were implemented via Skype owing to the fact that these participants were based outside the UK or could not be met in person. In consequence, there were challenges in the Skype interviews due to poor internet connectivity and the different dynamic between interviewer and interviewee due to their not meeting in person.

A key element of qualitative interviewing is ensuring flexibility, not just in the ordering of questions but also in terms of the resilience of the researcher in the face of unexpected challenges during implementation (see Bryman, 2008). Faulty recording equipment meant that two of the interviews could not be recorded, resulting in total reliance on the researcher's notes. Due to some of the participants' time constraints, it was not always possible to pose every question to each of the interviewees, but in these instances the researcher endeavoured to ensure key questions were answered – namely those directly about multi-hazard assessments.

Finally, two CAFOD UK staff were included in the study; thus their close connection to the EngD could be considered a bias. Therefore the researcher has attempted to ensure a balanced argument by not favouring the viewpoints of these respondents (which are more aligned with that of the researcher) over those of the remaining respondents. Indeed, the comments provided by each individual are highly insightful in terms of understanding the process and role of hazard assessment within the DRR and CCA work conducted by humanitarian and development NGOs, since most interviewees have good knowledge of the sector as a whole.

**Study B – interviews and scoping study to the Philippines**

The interviews were conducted as part of a scoping study to the Philippines between the 6th to the 28th September 2010, the additional purpose of which was to identify a case study for the second part of the research. The interviews involved NGOs based in Metro Manila, Legazpi City (the provincial capital of Albay) and Illigan City in Lanao del Norte (Mindanao; see Figure 3.4). The reason for targeting participants in these areas was owing to the fact that (1) the INGOs are based in Manila; (2) partners of one organisation included in Study A (HD INGO D; see Chapter 4) are located in Albay, which was proposed as a suitable case study owing to it being one of the most multi-hazardous provinces in the Philippines; and (3) because the researcher was invited to observe and participate in CAFOD's 'Regional Exchange of Southeast Asian CAFOD Partners on Climate Change Adaptation and Disaster Risk Reduction in Land Use Planning and Management' – a 6 day workshop held between the 18th and 25th September 2010 in Illigan City and Osamiz, Mindanao. The workshop is referred to as 'Regional Exchange Workshop' in Chapter 5.

In addition to the challenges outlined in the section above, challenges during the Philippines interviews related to language and cultural issues, and the fact that participants did not tend to share the same level of detail as those interviewed in the UK. The challenges are discussed in the context of both visits to the Philippines in the following section.

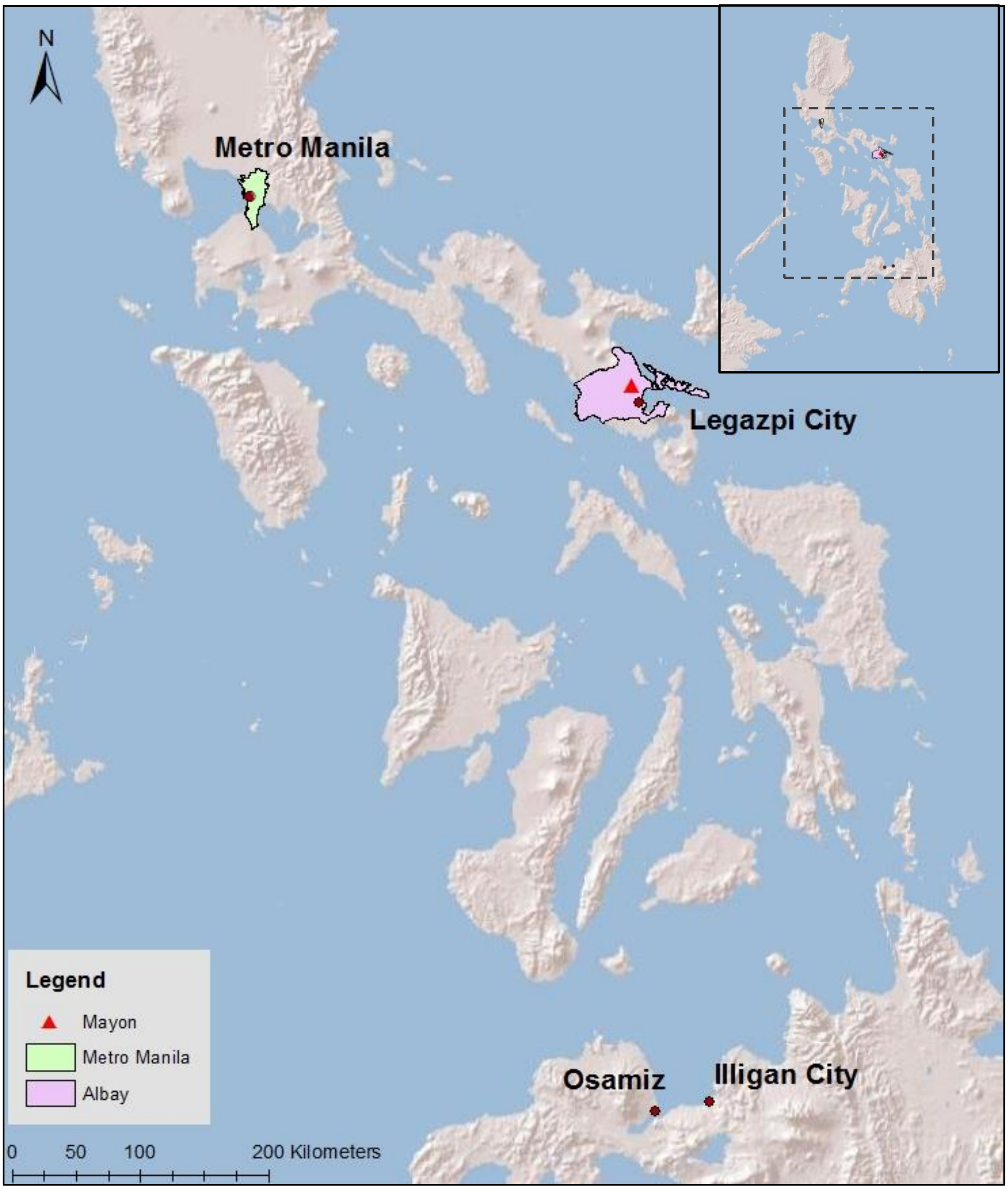


Figure 3.4 Location map of 2010 field visits. Source of data: Phil GIS (2013).

**Study C – case study interviews and field work**

The fieldwork for the case study was conducted between the 10th October and the 9th November 2013, with the five weeks spent between Metro Manila and Albay interviewing key stakeholders and making participant and field observations. The interview guide contained a number of prompt questions for each category, with the guides slightly differing between technical experts (scientists and local government), NGO practitioners and community members (Appendix C). All of the pre-arranged interviews were recorded, expect where one interviewee expressly requested there be no recording made. Two impromptu interviews were not recorded owing to the fact that these began as conversations, which developed into interviews but did not cover the extent of the interview questions.

It was envisaged that interviewees might use the interview as an opportunity to volunteer their experiences of Typhoon Reming; however most required prompting. *In situ* revision of questions by the researcher was necessary, owing to the emergence of new information during the interview or because interviewees struggled to understand the question being asked of them. Owing to time constraints on certain interviewees, not every question could be asked of every participant, but the researcher endeavoured to ask the most pressing questions. Interviewees generally tended to be reluctant to criticise other groups with true conviction, which is interpreted as their being uncomfortable to be fully open with the interviewer.

Whilst the aim was to conduct one-to-one interviews, circumstances often meant that interviews were conducted in pairs and, in the case of local communities, larger groups. The choice of interview location was beyond the researcher's control and, at times, meant that the interviewee was distracted by their surroundings, such as interruptions by family members and neighbours (see Mercer, 2006). During the group interviews, curious community members would often approach and become involved mid-way through the interview. These are just some of the realities of conducting research in this type of setting and are difficult to avoid. In order to negate the dominance of more confident or authoritative figures the researcher would direct questions to other members of the group to ensure their involvement. For transparency, the dominant speakers have been emphasised in Appendix G.

The challenges encountered during the field visit have implications for the quality of the data collected; whilst these challenges could not be avoided, they are important to highlight to ensure transparency. Whilst English is a formal language in the Philippines, most communities communicate in Tagalog or the local Filipino dialect. Translation took the form of either a disaster management officer from the municipal government or an NGO who was familiar with the community or, likewise, an NGO (as per Usamah and Haynes, 2012). Despite being briefed regarding the objective of the translation (i.e. verbatim translation), one NGO translator often provided their own answers and opinions whilst the other translators would, from time to time, undoubtedly nuance the answer with their own understanding of the issue. The quality of interpretation also varied owing to the different competencies in the translators' knowledge of English and their perception of how much the researcher understood of what had been said (communities often spoke in a mixture of Bicolano and English). Whilst the problems associated with this were unavoidable, the researchers' awareness aided her to differentiate between the opinions of the community and those of the translator, assisted by the fact that the local dialogue was interspersed with English. Future research in the Philippines would need to involve a dedicated and impartial translator who adequately understands the approach of qualitative research. Furthermore, it would be preferable to get a more even representation of age and sex by, for example, conducting interviews before or after working hours with the aim of interviewing more male participants.

In terms of the interviews with NGOs, local government and scientists, there was a range of levels of understanding of English and there were nuances in the meaning of a number of

English words. Given that English is mostly spoken by the more educated, it would have been deemed inappropriate to have requested an interpreter in these interviews. This is, perhaps, an unavoidable problem given that Usamah and Haynes (2012) also conducted their key stakeholder interviews in English. During the interviews, it became clear that (at times) respondents misconstrued the questions being asked of them; unfortunately, this was not always obvious until after the interview. When it was apparent during the interview, the interviewee attempted to clarify the question or follow up with additional questions but this did not always result in a successful understanding of the question by the respondent. It is evident that longer engagement and multiple meetings with those interviewed would have ensured more detailed responses and better understanding between the interviewer and respondent and is, as such, suggested for future research.

Accepting these inevitable challenges is part of being a qualitative researcher and, moreover, these problems are outweighed by the rich and detailed information interviews provide. Beyond being aware of the limits of the research, qualitative researchers must also be mindful of how they may have influenced and created bias in the research. Identifying these influences requires the researcher to be reflexive. This quality and other implications of interview research are discussed in the following section.

## 3.5 Critical reflexivity in social research

There are a number of influences that shape and have the potential to create bias in qualitative research (Figure 3.5) and it is only by being aware of these that the researcher has a true understanding of the results of the research. The influence of practical considerations, epistemology and ontology has largely been addressed; therefore the following discussion focuses on reflexivity – the recognition by the researcher that her own background shapes the interpretation (Valentine, 2005; Creswell, 2014).

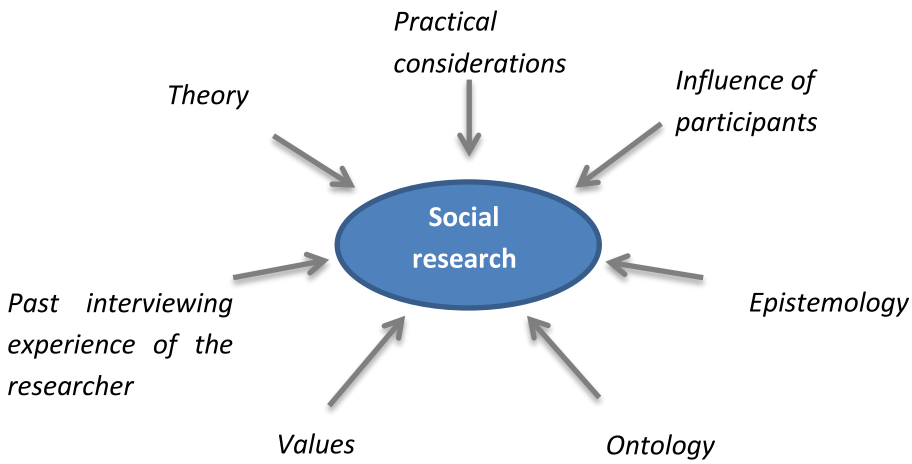


Figure 3.5 Influences on social research. Source: adapted from Bryman (2008: 24, fig. 1.3) using Creswell (2014).

Reflexivity involves the researcher reflecting upon how their biases, values and personal background shape their interpretations of a study (Creswell, 2014), how these relate to research participants and how they themselves are represented (Charmaz, 2006). Critical reflexivity is a strength of the evaluation of qualitative work, since it involves a 'conscious deliberation of what we do, how we interpret and how we relate to subjects' (Baxter and Eyles, 1997: 505). The values of the researcher can and will intrude upon a number of components of the research process from formulation of the research question to the interpretation of data and the conclusions made (Bazeley, 2007; Bryman, 2008). Some of the obvious points at which the researcher may have unwittingly influenced the research process through accident or design are discussed below and two 'reflexive diary' extracts written by the researcher are provided in Appendix D.

The researcher's own values and belief systems reflect her training as a natural and physical scientist, which made her a suitable candidate for a research project focused upon multi-hazards but also meant that her prior assumptions regarding social research may have intruded and biased the research. Having these influences in the forefront of her mind ensured that she had an open view to the identification of key themes from the interview findings.

In addition to her own values, her being a researcher may have affected the perceptions of participants, especially because it transpired that some regarded scientists as being at times disconnected with the needs of the humanitarian and the development sector (see Chapters 4 and 5). Conducting research as part of an academic-NGO partnership undoubtedly influenced the research process, since NGOs are driven by practical application rather than academic discourse. Being associated with CAFOD may also have affected how other NGO interviewees perceived the researcher and the information they were happy to share. NGOs are in competition with each other for funding and are often 'entangled within alliances and/or rivalries based on personalities and institutional histories' (Mercer, 2006: 97).

Furthermore, interviewing in less developed countries necessitates a heightened sensitivity to the complex power relations that exist between researchers and interviewees, as well as to local codes of behaviour (Valentine, 2005). The researcher was acutely aware of these influences during both visits to the Philippines, particularly during the first visit it was realised that some interviewees appeared uncomfortable when asked to sign consent forms since they placed more emphasis upon unspoken trust. There was also a sense during some of the community visits that the NGO gatekeepers wanted communities to endorse the beneficial work of the NGO to the researcher.

## 3.6 Ethical considerations

Whilst qualitative research necessitates that certain aspects of the encounter with individuals must be crafted, it is also essential that the rights (both formal and informal) of the respondent are taken into consideration (McCracken, 1988). As a UCL student, the researcher was bound by the ethical frameworks of both the university and the research council (Engineering Physical

Sciences Research Council) as well as those of the research partner (CAFOD). However, it is acknowledged that what is deemed ethical by a university may differ from that of a humanitarian organisation because they operate under different frameworks and approaches (see Duncan et al., 2014). One of the major ethical components of this research is the fact that the partner also comprises one of the subjects of the research, which can make it difficult to be critical of their work in support of the research (Mercer, 2006).

Four areas of ethical concern in qualitative research include whether harm comes to participants, the avoidance of deception, the need for informed consent and the invasion of privacy (Bryman, 2008; Dowling, 2010). The approach and content of the research minimises the first point, however they each warrant further discussion.

### 3.6.1 The principle of 'do no harm'

Ensuring harm does not come to participants is a principal concern in NGO code of conducts as well as research ethical frameworks (e.g. UCL, 2014a). However, these may be juxtaposed; in research this may involve weighing up risk of harm with the benefits in the research, whereas the principle of NGO practice of 'do no harm' is underpinned by their mandate to improve the lives of others (Duncan et al., 2014).

The only element of harm within this research was possible 'psycho-social' harm – in other words raising issues that may be upsetting or potentially psychologically damaging to participants (Dowling, 2010). The risk of this impact applies to the interviews with communities about the impact of the case study disaster, so only general questions with regard to how they were affected by the disaster were asked, rather than enquiring about specific issues, such as whether family members were killed. The researcher was also sensitive in her manner of asking questions, judging when it was inappropriate to probe further, especially during instances when the information required was contextual but not critical to the analysis (Stake, 2000).

In general, the potential harm to participants was deemed minimal; the participants interviewed are ‘healthy adults’ who were interviewed about hazard assessment practices and professional experiences and therefore were not asked personal details beyond their name, occupation and their background related to their work. More background information was requested of communities in order to give context to their answers, but this information was not largely intrusive nor is it sensitive. Furthermore, Studies A and B were decreed exempt from ethics approval by the UCL Research Ethics Committee, whilst Study C was given ethics approval under the criteria of minimal risk under the UCL Research Ethics Committee Terms of Reference (UCL, 2014b). The data were stored in accordance with the UK Data Protection Act 1998 in order to maintain trust with participants; however this legislation was meaningless to the Filipino participants as there is no equivalent act in their country. As such, the interview transcripts are not included as an Appendix as it is not possible to guarantee participant anonymity throughout these scripts.

In Studies A and B, participants were told that they would be made anonymous, however in Study C they were given the option as many Filipino participants interviewed during the scoping visit were surprised by the fact that they would be anonymised. However, despite the minimal implications of the research, in the end all professional participants were made anonymous in the discussions of findings as a matter of respect for their honest criticism of respective organisations.

### 3.6.2 Avoiding deception through informed consent

The researcher provided each respondent with an information sheet explaining the purpose of the study, how the information they provide will be used and stored and their right to leave the study at any point. Each interviewee also signed a consent form, agreeing that the data they provided could be used for the purposes of this and future research, and notifying them that their responses would be kept anonymous (see Appendix E for forms). In terms of observations, it is more difficult to ensure informed consent; however, this is recognised as being a legitimate exemption of the need for informed consent (Dowling, 2010). As was discovered during the scoping trip to the Philippines, informal mechanisms of information sharing are the norm in the Philippines which explains why some participants (in particular the scientists) could not understand why written agreement was required.

In terms of gaining consent from the communities, the researcher asked the gatekeeper (NGO or local government official) whether they thought written or verbal consent was more appropriate. In some cases, it was deemed more appropriate for the community to be informed about the research and what their giving consent entailed and then to verbally agree. Proof of their agreement is provided by a consent form signed by the facilitating official.

### 3.6.3 Invasion of privacy

In the case of this research, the questions focus upon a process (hazard assessment) and an event (typhoon triggered lahars). As such, the questions asked are not particularly private, save for some background information about the participant.

Wallace (1997) conducted interviews with NGOs on changes in development policies and practices and found that the openness and self-critical discussions NGOs were happy to have internally was not replicated when the discussions moved to a public arena. Given Wallace's experience, the decision was made to anonymise their and other professional participants' answers. It is acknowledged, however, that certain answers may be indicative of the identity of the participant, especially to those familiar with the field. Every effort has been made to avoid this.

In terms of communities, they are referred to by their first name and village (Barangay) since they were given the option to be anonymised or not. The reason for not fully anonymising them is that there is no ethical reason for not referring to them by first name and location.

## 3.7 Analysing qualitative data

It is generally considered that interviews should be transcribed verbatim (Dunn, 2010). However, during any conversation, people rarely speak in fully formed sentences: they often repeat themselves or are hesitant (Bryman, 2008).

For the benefits of the reader some of the hesitancies are removed in the quoted evidence and words are inserted to bring clarity, especially in the case of interviews where the participants' first language is not English. Any hesitancy or text removed (so as to reduce the size of the quotation) is indicated by ellipsis, whilst inserted text is indicated by square brackets.

### 3.7.1 Coding qualitative data

Coding is the starting point for most methods of qualitative data analysis (Bryman, 2008). The purpose of coding is to select, separate and sort data in order to begin the challenge of determining what they mean (Charmaz, 2006; Bazeley, 2007). Charmaz (2006) states that coding forms the analytic frame upon which the analysis is built and, as such, should begin in a very open manner – breaking down, examining, comparing, conceptualising and categorizing the data (see Strauss and Corbin, 1998). In general, most coding strategies employ a structure that begins with the numerous codes that emerge, which are assimilated into categories and sometimes concepts and theories (Bazeley, 2007).

Grounded theory embraces a process of coding that builds initial concepts through constant comparison with the data, building categories (a concept regarded as representing real-world phenomena) and hypotheses (initial hunches about relationships between concepts) and theorising (Bryman, 2008). The process beings with open coding (often of individual words), followed by focused coding, which is more directive, selective and conceptual (Charmaz, 2006). Coding in this manner is, however, criticised by some writers for being too fragmentary, resulting in a loss of sense of context (e.g. Coffey and Aitkinson, 1996). Furthermore, Bryman (2008) states that many claims to a grounded theory approach result in the identification of concepts rather than theories. Indeed, the research focuses upon the identification of themes rather than theory and therefore relates more to a thematic (content) analysis approach, which is increasingly regarded as an alternative, but closely linked, means of coding and analysing qualitative data (Bryman, 2008; Creswell, 2014).

Burnard et al. (2008) states that in thematic content analysis, open coding involves reading each transcript and making notes or short phrases that summarise what is said within the text. Cope (2010) suggests that coding includes 'descriptive codes' (category labels) that express themes or arrangements that are more obvious or directly voiced by the respondent and 'analytic codes' that highlight issues and themes that intrigue the researcher or have emerged as significant. Bazeley (2007) goes one step further to suggest that codes can be descriptive, topical or analytical. Without being overly concerned with the labelling of the technique employed here, arguably the researcher follows a thematic content analysis with elements of a grounded theory approach, adopting procedures outlined by Bazeley (2007), Bryman (2008), Creswell (2014) and, to some extent, Charmaz (2006) for coding and interpreting data.

### 3.7.2 Coding scheme and strategy

Both descriptive and analytical codes were adopted in order to analyse the qualitative data, the former relating specific areas of enquiry (e.g. 'toolkit development') and the latter to the themes that emerged (e.g. 'scale'). Owing to the volume of interview data, qualitative data management software was utilised (NVivo), as it facilitated the management and retrieval of coded data. The pitfalls of electronic coding were acknowledged, including the danger of ending up with more codes than are manageable (Bazeley, 2007). The software supported the complimentary analysis of the interview data in terms of memo-writing, annotating text and auditing (within NVivo, a journal was kept of significant decisions and reflections upon the coding process; see Bazeley, 2007).

Owing to the identification of themes within the literature, some of the codes were *a priori* (see Bazeley, 2007), whilst others emerged during the analysis process. The researcher opted to code entire phrases, sentences and – at times – paragraphs to avoid overly fragmenting the data and losing too much of the contextual meaning (*cf.* Coffey and Aitkinson, 1996). The codes were revised as each transcript was analysed and the coding scheme was refined through the re-coding of the same interviews until the researcher was convinced the meanings were well represented by the codes. All three studies employed qualitative coding, categorising and theme building and an example of the codes that were adopted for the analysis of the Study A (and largely Study B) is given in Figure 3.6. The descriptive codes are shaded blue; analytical codes are shaded brown, with sub-codes being indicated by the use of ellipse shapes. The attribution of each of these sub-codes to the primary code is indicated by a line. Ultimately, all the codes are linked since the analytical codes emerged from the responses to the descriptive codes.

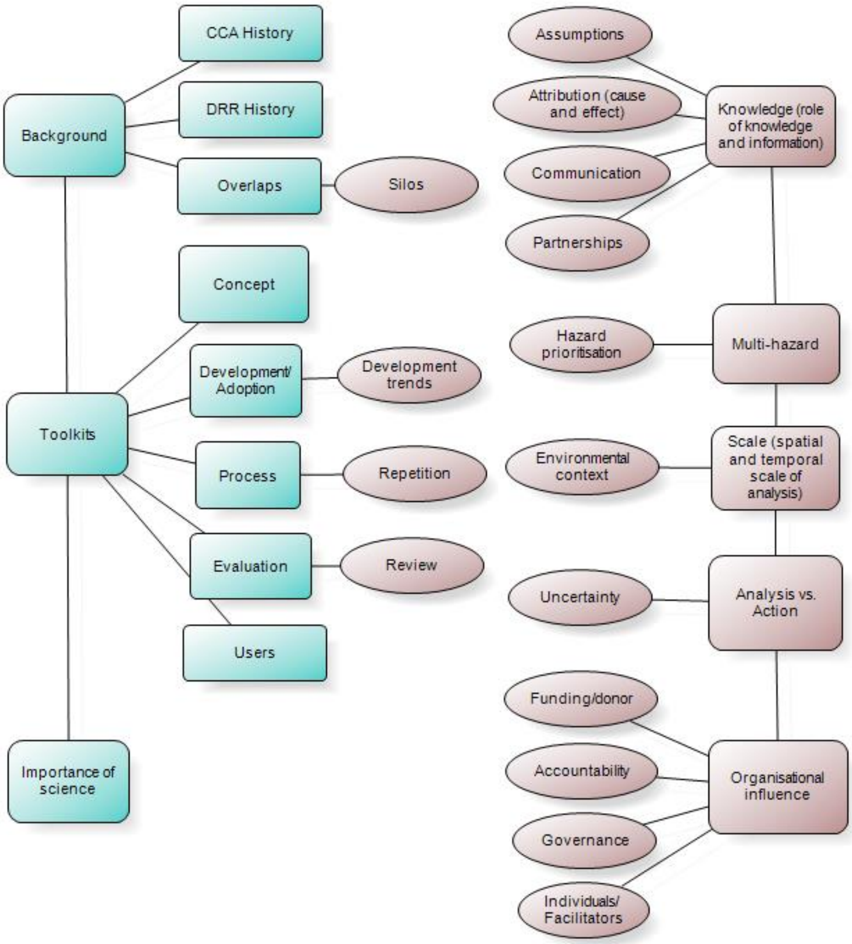


Figure 3.6 Diagram of descriptive and analytic codes assimilated into categories and themes respectively identified during the analysis of Study A. The diagram was created using NVivo.

## 3.8 Summary

Qualitative research is challenging to define and implement but incredibly rewarding; it provides researchers with the means to explore topics that have largely received little attention to date. The research is driven by pragmatic concerns and practical needs and this reflects the choices of methodology and methods adopted for this research (see Table 3.11). Semi-structured interviews, informal meetings, secondary data and information and observations were selected as a suitable means of exploring to what extent NGOs are assessing multi-hazards and a case study of the reality of multi-hazards and what their assessments entail. These methods are a means of triangulating the research and the description of their implementation ensures a rigorous and transparent approach to research was adopted. The research emphasises the importance of an ethical and reflexive approach. The decision to address the research question in two complementary parts reflects the nature of interdisciplinary research, which necessitates a problem to be addressed from more than one angle.

Table 3.11 Summary of the research approach.

| ***Research design*** | ***Part one*** | | ***Part two*** |
|---|---|---|---|
| | ***Study A*** | ***Study B*** | ***Study C*** |
| *Approach* | Qualitative | Qualitative | Mixed |
| *Methodology* | Grounded | Grounded | Case study |
| *Methods* | Semi-structured interviews; informal meetings, participant observations, secondary data. | Semi-structured interviews; informal meetings; participant and field observations, secondary data. | Semi-structured interviews, field observations and quantitative secondary data analysis. |
| *Target group* | 26 interviews with NGOs and researchers developing and implementing tools for hazard assessment (additional informal meetings with donors and humanitarian/development practitioners). | Nine formal interviews with local and INGOs (17 informal meetings with donors, local and INGOs, scientists and local government). | 26 interviews with scientists, local government and NGOs involved in the case study. One to one and group interviews involving 46 community members. |
| *Location of study* | UK | Manila, Albay and Mindanao (Philippines) | Manila and Albay (Philippines) |

The following two chapters present the findings from the first part of the research and chapters 6 to 8 introduce and discuss the findings of the case study. The approach to presenting the qualitative information is a combination of findings with some initial discussion (see Burnard et al., 2008) before synthesising parts one and two in a final discussion in Chapter 9.

# Chapter 4: UK-based analysis of NGO hazard assessments

Chapters 4 and 5 present the findings from the analysis of the interviews conducted as part one of this research. The purpose of this analysis was to determine:

(1) whether and how NGOs are conducting multi-hazard assessments;

(2) whether they use science for this purpose;

(3) what factors constrain or enable their ability to implement these assessments.

Chapter 4 presents the findings from the interviews from Study A (Head Office and three 'in-country' international NGO (INGO) representatives), which were conducted in the UK. The findings from Study A are then compared with the interviews with NGO practitioners in the Philippines in Chapter 5, in order to determine whether the findings from Head Office reflect those from the field.

The results presented are supported with example quotations from the interview transcripts. Interviewees are referred to as interviewees, representatives or participants with 'Head Office' referring solely to participants from Study A. 'In-country' participants refer to those based in INGO country offices or local agencies in the Philippines.

The analysis begins with some background to the participants. Section 4.1.2 introduces some of the institutional barriers to implementing multi-hazard assessments, focusing upon how the agencies represented are engaging with DRR and CCA since both are insightful as to how they consider multi-hazards. The approaches, scale, process and review of hazard assessments are then critiqued, in order to determine the extent to which multi-hazards are realistically being assessed. Section 4.1.4 explores the sources of information and knowledge included in the assessments. Study A concludes with the proposal of three developing answers to the three objectives above.

## 4.1 Background to interviewees

Table 4.1 outlines the participants interviewed, including some background to their organisations. Participants are referred to by their job description and the type of organisation they work for. During the discussions it is indicated if a finding is more indicative of the three interviewees who work in-country or those working in the Head Office.

The majority of interviewees represented humanitarian and/or development international NGOs (HD INGOs). The NGOs vary in size and capacity, but all represent major and far-reaching international NGOs operating across Latin America, Africa and South-east Asia. Owing to their involvement in creating toolkits utilised by NGOs there is also the inclusion of one conservation NGO representative, one consultant (who previously worked for one of the HD INGOs interviewed) and two researchers. Whilst a number of organisationally branded tools were discussed, these are collectively referred to as participatory hazard, vulnerability and capacity assessments (PHVCAs) so as to make interviewees less identifiable.

The purpose of interviewing participants from both DRR and CCA backgrounds (Table 4.1) was because both had packaged methods ('toolkits') for the purpose of assessing community vulnerability and capacity to natural hazards and environmental change and that these toolkits adopted similar participatory processes of analysis. Analysing participants' and their organisations' positions with regard to DRR and CCA provided insight into their perceptions of hazards and highlighted the prior assumptions being made with regard to the hazards and threats communities need to be addressing.

Table 4.1 Participants in Study A. HD INGO is the acronym used to represent humanitarian and development international non-governmental organisations. CC refers to climate change.

| ***Organisation*** | ***Operations*** | ***History of Engagement*** | | ***Respondent*** | ***Date of interview*** | ***Location*** | ***Developed Tools (Y/N)*** | ***Interview recorded (Y/N)*** |
|---|---|---|---|---|---|---|---|---|
| | | **DRR** | **CCA** | | | | | |
| ***(HD) INGO A*** | Direct; work with but not through partners | [No date given] | 2008 | ***Director – humanitarian team*** | 01/03/2010 | UK | Y | N |
| ***(HD) INGO B*** | Partners | 2008 | 2007 | ***Regional Programme Manager – DRR*** | 23/03/2010 | Nicaragua | N | Y |
| | | | | ***Adviser – DRR*** | 20/05/2010 | UK | N | Y |
| | | | | ***Adviser – CC*** | 25/05/2010 | UK | N | Y |
| ***(HD) INGO C*** | Partners and direct operations | Early 2000s; 2005/6 established risk reduction working group | 2007 (became strategic approach; programmes new and *'thin on the ground'*) | ***Adviser – CCA*** | 28/06/2010 | Canada (in France at time of interview) | Y | Y |
| | | | | ***Team leader - Climate change and hunger team*** | 03/06/2010 | UK | Y | Y |
| | | | | ***Developing and training on CCA tool*** | 30/07/2010 and 06/08/2010 | Kenya | N | Y |
| ***(HD) INGO D*** | Partners; country offices | 2006 | 2007/8 (mitigation: 2004/5) | ***Policy and research Adviser – DRR*** | 12/01/2010 | UK | Y | Y |
| | | | | ***Adviser - Climate Change Programme*** | 20/01/2010 | UK | Y | Y |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***-*** | N/A | N/A | N/A | ***DRR Consultant*** | 01/04/2010 | USA | Y (prev. worked for an NGO) | Y |
| ***(HD) INGO E*** | Partners | Post-2003 – wrapping up linking relief and development programme – finalised in 2005 | [Did not state] | ***Adviser – DRR*** | 30/04/2010 | Philippines | Y | Y |
| ***Advocacy INGO for DRR*** | Network members | Since beginning (2007) | N/A | ***Network coordinator*** | 16/12/2009 | Global Advocacy for DRR | Y | Y |
| ***Research institute A*** | - | [Did not state] | Believes climate change came first | ***Team leader – CC*** | 02/08/2010 | Research | Y (screening projects rather than conducting PHVCA) | Y |
| ***Research institute B*** | - | Not a core programme | 2001 (climate change and energy project) | ***Senior researcher (CC more than DRR)*** | 15/08/2010 | Geneva | Y | Y |
| ***(HD) INGO F*** | Partners and direct operations (relief work) | 5/6 years ago formed DRR operations | Overlap with DRR unresolved | ***Programme Policy Management Team member – DRR*** | 02/08/2011 | UK | Y | Y |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***(HD) INGO G*** | Partners and direct operations | 2006 | [Working on but did not state] | ***Policy Coordinator – DRR (formally DRR Project Manager)*** | 05/03/2010 | UK | N (developing) | Y |
| | | | | ***Adviser – CC and DRM programme*** | 20/03/2010 | Philippines | N (just use lots of tools) | Y |
| ***Development INGO*** | Partners and direct operations | Several decades ago (10-20 years) | 2003 (first meeting then 2-3 years later recruited campaigner; now team of two) | ***Policy Adviser – CC*** | 12/01/2010 | UK | Conceptual framework for adaptation, rather than tool | Y |
| | | | | ***Project Manager – Livelihoods and Disaster Management*** | 15/01/2010 | UK | Final stages of development (resilience tool) | Y |
| ***(HD) INGO H*** | Partners (few direct operations) | 2005/6 (working on as early as 2003; policy work 2004) | 2007/8 (early 90s started hearing form partners that weather changing) | ***Adviser – DRR*** | 16/12/2009 | UK | Y | Y |
| | | | | ***Research and policy officer (advocacy for DRR)*** | 21/12/2009 | UK | | Y |
| | | | | ***Director - Disaster Management Team*** | 21/12/2009 | UK | | Y |
| | | | | ***Adviser - Environmental sustainability*** | 18/01/2010 | UK | | Y |
| ***(HD) NGO I*** | Direct (view to local autonomy) | [No date given] | Overlap with DRR unresolved | ***Director - DRR and Community Resilience*** | 04/03/2010 | UK | Y | Y |
| ***Conservation NGO*** | Partnership with Humanitarian INGO | 2004 | ~2005 | ***Team leader - Climate Adaptation and DRR*** | 28/10/2010 | USA | Y | Y |

## 4.2 Institutional influences on multi-hazard approaches: perceptions of DRR and CCA

The NGOs represented began addressing DRR and CCA at similar points (see Table 4.1) and the interviews came at a time when agencies were trying to resolve the overlap between these two communities of practice. Many NGOs were looking to move away from organisational silos to more integrated approaches to addressing risk:

> *'I got together with our DRR staff and basically said...you are half right in saying DRR covers it* [climate change] *but you can't actually have another box saying this is adaptation we'll just create another specialisation and we'll have...everybody working in their little silos and not thinking about the other issues. So what we've really tried to promote is a much more integrated approach....'* (Adviser – Climate Change Programme, INGO D)

Nonetheless, several interviewees remarked upon the growing emphasis upon CCA within the sector[1]. Many interviewees noted that the decision to focus work on adaptation was also owing to their concern over what climate change means for existing projects, fuelled by the international narratives as well as what they and their partners were witnessing on the ground:

> *'he was actually pushing a fairly half open door and as soon as the partners began to understand the science behind climate change they immediately started to say: "that explains a lot of what we have been seeing."'* (Adviser – Climate Change Programme, INGO D)

As such, it is difficult to fully determine whether developing toolkits for CCA was driven by changes on the ground attributable to climate change or due to prior perceptions that these changes were caused by climate change. During the interviews there was a sense that all changes in weather, environment and meteorological hazards were attributable to climate change:

[1] INGOs F and H have made it a corporate priority

*'everyone seeing that seasons were changing, freak storms changing, not as predictable...we thought far more than coincidence and through that stumbled across climate change'* (Adviser – Environmental Sustainability, INGO I)

Four interviewees[2] noted a degree of 're-branding' of DRR approaches that occurs, which is possibly owing to the urgency (particularly emphasised by one interviewee[3]) behind developing tools for addressing CCA and the pressure from donors:

*'all of a sudden we jumped from…talking about DRR and started banding around the language of CCA and if you're just a practitioner or one of our partners* [they ask:] "*what's all this about?" and so what we had to say is "you are doing so much of it already" it is nuancing but we need to nuance because we need to recognise things a little bit more as an organisation but also for our donors and recognising the way that the whole external environment is going.'* (Director – DMT, INGO H)

Two in-country interviewees[4] commented on the fact that DRR and CCA are concepts that come from 'the north' and it was observed that communities are not readily concerned with the abstract categorisation of risk as adopted by humanitarian and development agencies[5]:

*'But for the development arena or sometimes NGOs or development agencies are also divided into the perspective…but at the community level it doesn't matter to them if it is climate change or* [DRR]*…they look at things as one integrated thing rather than* [a] *different ball game.'* (Adviser – DRR, INGO E)

The relative autonomy of in-country staff poses a challenge in terms of transferring thinking at Head Office to the ground. Whilst this might be especially true for those agencies adopting a partnership based approach (noted by the Climate Change Adviser at HD INGO B), two interviewees remarked on this problem for operational organisations:

*'centrally there's much more emphasis on climate change than DRR…*[INGO F's] *not a kind of a very directive organisation on the ground…in the country level, in the regional level, you know the countries decide pretty much themselves where the resources are*

[2] Adviser – CCA (INGO B); Adviser – CCA (INGO C); Adviser – DRR and Director – DMT (INGO H); Policy Coordinator – DRR (INGO G)
[3] Adviser – Environmental Sustainability (INGO H)
[4] Regional Programme Manager – DRR (INGO B); Adviser – DDR (INGO E)
[5] Policy Coordinator – DRR (INGO G); Project Manager – Livelihoods and Disaster Management (Development INGO)

*needed there are many there are more DRR people on the ground'* (Programme Policy Management Team Member – DRR , INGO F)

The DRR Adviser from INGO B felt that there was no need to label projects as climate change and that incorporating climate change is about doing development projects *'a little bit more appropriately.'* Furthermore, two interviewees[6] did remark that climate change might not be the only factor driving environmental change at the community level and another two were concerned with the bias this may bring to the assessment process[7]. Moreover, approaches to the practical application of CCA described tended to address climate variability (e.g. seasonal forecasting and climate hazards) more than climate change and, as such, differentiation on the ground is not widely apparent (*cf.* Schipper and Pelling, 2006). In spite of this, Head Office interviewees generally appeared to perceive CCA as requiring quite a different analytical approach, particularly because most associated climate change with an uncertain risk future compared with DRR:

> *'…there is a distinct difference, I mean climate change adaptation or adaptive capacity has to build in this uncertainty about what the future is. DRR functions looking at known hazards based on previous history, how people have responded, how can we make people more resilient to the known impact, or pretty well known impact. Whereas climate change we don't know.'* (Policy coordinator – DRR, INGO G)

The above quotation also indicates that the move towards creating tools for CCA projects is driven by available funding and not analytical objectivity. Furthermore, the interviewee does not account for the fact that communities might not have experienced all the hazards that affect their location. By emphasising the 'known' impact of DRR hazards compared with climate change, the interviewee does not appreciate the uncertainty of multi-hazards, where hazards might occur simultaneously or in close succession resulting in an overall impact that is much larger than the 'known' impact of the individual hazards (*cf.* Marzocchi et al., 2009). The

[6] Adviser – Climate Change Policy (Development INGO); Environmental Sustainability (INGO I)
[7] Team Leader – Climate Change and Hunger; Adviser – CCA (both INGO C)

mind-set above is consistent with the criticism of DRR in the sense that it is concerned with historical hazards, planning for the short-term and addressing known risk (Few et al., 2006).

Fundamentally, INGOs are concerned with implementation, and it appears as though the driver for developing toolkits has come from a need to address how to do adaptation or DRR, rather than perhaps an initial objective assessment of the risk. Moreover, the beliefs behind climate change and DRR mean that toolkits for assessing multi-hazards already embody assumptions about the type of hazards and their dynamic nature, with anticipating future risk and emergent threats being considered much more in the context of CCA tools.

## 4.3 Hazard assessments: a critique of approaches and methods

Interviewees were asked about their toolkits for PHVCA in the context of assessing hazards, with specific questions on organisational toolkits posed if the interviewee had access to them prior to interview. With regard to the CCA tools, some are classed as climate screening tools, in other words reviewing development strategies against possible climate change; however all but one of the tools discussed adopts participatory processes for hazard assessment.

Most interviewees indicated that toolkits are designed to emphasise the importance of assessing and understanding root causes of vulnerability, utilising participatory processes of assessment and resulting in an action plan that communities can implement to begin reducing their risk. Toolkit users were perceived to be NGO programme staff or partners. These groups will facilitate the process of PHVCA with the community, sometimes with the assistance of trained community representatives[8]. All but one interviewee[9] stated that their methods adopt a multi-hazard approach, the exception being due to the fact that their tool was specifically designed to analyse large-scale donor programmes for climate risk. The two interviewees in

[8] Team Leader – Climate Change and Hunger Team (INGO C); Director – DRR and Community Resilience
[9] Team Leader – Climate Change Programme (Research Institute A)

the Philippines particularly emphasised multi-hazards as an integral part of their approach. Only two agencies had not developed their own set of tools, although one of them was in the process of doing so (Table 4.1). Each toolkit reflects the ethos and approach of the organisation and/or individual developing the approach, but most adopt similar methods:

> *'A lot of these things have arisen naturally within the different countries and I think the whole participatory movement in development is pretty much worldwide, thanks to* [Robert] *Chambers. I mean this is really an attempt to have a uniform approach throughout the organisation.* [NGO] *have their one,* [NGO] *have their way of doing things. And when you look at them so much of it is common to each other. It is all based on enquiry, participatory enquiry…for communities.'* (Project Manager – Livelihoods and Disaster Management, Development INGO)

The limited feedback on toolkits interviewees shared was generally good and CCA toolkits were particularly well received, but some bias was noted as CCA toolkits were often implemented in areas already identified as being vulnerable to climate change:

> *'we don't specifically ask about climate hazards – we ask about hazards in general; but what we found in most of the communities where we've used the handbook is that climate hazards tend to top the list and that's somewhat biased because we [were] obviously using it in places where we identified climate as an issue.'* (Adviser – CCA, HD INGO C)

Interviewees perceived their toolkits as flexible guidance to be adapted for particular contexts, with the DRR Policy Coordinator from INGO G particularly emphasising the process rather than the tools. However, couching risk in certain terms challenges the claim that the tools are designed to capture multi-hazards:

> *'We, again like a lot agencies, we realise things move on, the times have changed, the challenges are new, they are more intense, new strategies, new threats require new responses, and that was why we thought vulnerability and capacity analysis with the climate focus, with the climate lens, was necessary.'* (Team leader - Climate change and Hunger team, INGO C)

This same interviewee also claimed that:

*'It kind of leaves the discussion open, so for example in the participatory exercises we don't specifically ask about climate hazards, we ask about hazards in general'* (Team leader - Climate change and Hunger team, INGO C)

However, the assumption that methods are neutral and will therefore capture all hazards does not always transfer from the developer to the implementer owing to the fact that toolkits are designed for a particular purpose. One interviewee noted that their tool, which is packaged as a tool for CCA, was designed to be quite open to incorporation of multiple hazards, but a member of staff in-country implied that it had been used solely in the context of climate change:

*'So far we haven't – or maybe speak for myself – I haven't like really used it deliberately with the DRR community.'* (Kenyan staff, INGO C)

In reality, toolkits are designed for a particular purpose and whilst attempts are made to capture wider perspectives through cross-department consultation during the development of toolkits[10], this may not be systematically carried out. Moreover, this consultation does not include hazard specialists.

The need to adopt a DRR or CCA analytical lens is influenced not only by the institutional and organisational paradigms and approaches, as well as the assumptions of the developer, but also owing to the need to constrain participatory methods of analysis. The irony is that participatory processes are designed to be unstructured and emergent, yet this very quality makes them incompatible with organisational capacities (Twigg and Bottomley, 2011). The challenge appears to be that NGOs are trying to manage the suite of problems faced by communities:

*'one of the challenges that we find that to do good climate change analysis…* [and] *DRR, it's a heavy process so the challenge when you're trying to find the kind of silver bullet of a tool or process that looks at all risks and all issues* [is that] *it just becomes*

[10] Adviser – DRR (HD INGO H)

> *more and more cumbersome'* (Programme and Policy Management Team Member – DRR, INGO F)

However, the lenses applied to focus assessments may serve to limit multi-hazard assessments by, for example, emphasising climate change and climate hazards at the expense of other hazards. Furthermore, framing methods in this manner undermines the assertion of NGOs that they are moving toward an integrated approach to risk reduction. The following discussion explores the scale, process and review of hazard assessments.

### 4.3.1 Spatial scale of assessments

Chapter 2 indicated that NGO risk assessments are primarily conducted at the community level; however, given that the natural systems that might impact communities go beyond these restricted spatial scales, it is necessary to determine whether NGOs are considering this wider context.

All the interviewees with the exception of one (whose tool was designed for project portfolio screening for climate change) stated that the hazard assessment would be implemented at the community level. When asked about the implementation of larger (e.g. national) scale assessments, it was apparent that most agencies undertake some form of national overview, but these pertain more to analysis of the institutional setting and poverty context (*cf.* Ruiz, 2010), and only include a broad overview of hazards and risk, which lack analytical depth:

> *'I think we used more the findings on the institutional landscape etc. rather than the actual findings on the hazards.'* (Policy and Research Adviser – DRR, HD INGO D)

Two interviewees[11] suggested that the PHVCA process applied at any scale. INGO G's Policy Coordinator for DRR said that they do address national risk assessments and another interviewee gave the example of prioritisation of countries based on one factor – climate change risk – rather than a multi-hazard analysis:

[11] Humanitarian Team Director (HD INGO A) and DRR Regional Programme Manager (HD INGO B)

*'Those 17* [priority countries] *are the ones in climate hot spots – we've done a sort of scanning exercise using various sources of climate risk, global climate risk analysis and come up with these sort of key areas'* (Adviser – Climate Change Programme, INGO D)

In general, regional or national level assessments of multi-hazards are not implemented, and hazard profiles are, therefore, not readily utilised as a means of identifying areas to target projects:

*'Risk as a sort of measure of strategic prioritisation has not been one of the primary things we sort of, we use, and we still don't use it and that's largely what I am trying to bring into being I guess. It's more a social analysis, socio-political analysis that doesn't necessarily look at the issue of risk that would determine where and how we develop development programmes.'* (Director – DRR and Community Resilience, INGO I)

Two interviewees[12] implied that those poorest would also be most at risk, however the Climate Change Adviser at INGO B challenged this assumption, and two others[13] emphasised the need to understand what people are at risk from. But, one interviewee emphasised that national risk assessments would make little difference as to where they support projects owing to their working through partners:

*'I mean say you did a really comprehensive hazard assessment that went into the country strategy papers, if the partners aren't saying that you know whatever it is a real hazard I don't think we would, we might use that information to inform partners but I don't know how much it would change things…'* (Adviser – CC, INGO B)

Arguably, however, this should not negate an INGO from having a thorough understanding of the multi-hazard profile of the country within which they work, thereby identifying where they, as INGOs, should be focusing and not just basing this decision on where their existing partners are working. One organisation[14] is moving towards more comprehensive assessments of risk at the national level (and HD NGO H are also considering this) but this appears more to

[12] Programme Policy Management Team Member – DRR (INGO F); Adviser – CC Policy (Development INGO)
[13] Adviser – CCA (INGO D); Adviser – DRR (INGO E)
[14] INGO I

have stemmed from the work and passion of an individual rather than changes in the approach of the organisation.

Discussions around natural system scales, particularly water basin management, emerged during the interviews. Three[15] interviewees noted the need to consider processes and interventions upstream of communities in terms of how these might affect the hazard profile; however one of these interviewees represents a conservation organisation and noted that these organisations tend to work on much larger spatial (ecosystem) scales than those adopted by humanitarian organisations. In the context of climate change, agencies were growing more aware of the need to consider the wider environmental context, which could be an important enabler for their assessments to capture multi-hazard characteristics like amplification (see Chapter 2). The DRR consultant mentioned a need to address this 'middle scale', advocating for something like a watershed approach and interviewees in INGOs C and H discussed ecosystem approaches. Three interviewees[16] indicated that NGOs needed to better their assessment of the environmental impacts of their work:

> *'Most humanitarian development NGOs would probably admit that we've all neglected the role of environment as a risk factor and as a solution and I don't know of many agencies that systematically do good environmental impact assessment* [EIA]*...but to do a proper EIA takes a long time – three weeks and it's a costly process. It's a challenge for us.'* (Programme and Policy Management Team Member – DRR, INGO F)

The above admission suggests that agencies are not committed to the time frames of rigorous analysis and that there is a gap in their capacity to assess the environmental processes that might affect the incidence of natural hazards and explain changes in local climate.

[15] Adviser – Climate Change (INGO B); Project Manager – Livelihoods and Disaster Management (Development INGO); Team Leader – Climate Adaptation and DRR (Conservation NGO)
[16] DRR Programme Policy Team Member (INGO F); the Kenyan representative of INGO C; Director – Disaster Management Team (INGO H)

One interviewee[17] felt that a larger scale analysis would mean losing sight of the differential impacts of disasters across communities, whilst another felt that, in order to determine the wider context, it is necessary to aggregate detailed local information:

> *'Ecosystem management I guess is a large scale concept, but I think, you know you can see it as sort of an aggregate of much more localised interventions and so that's sort of the approach we took, the analysis only makes sense, so it really holds together if you get this detailed information that ends up being very community...'* (Senior Researcher – CC, Research Institute B)

However, this presupposes that all communities will be consulted in a region, which has been found not to be the case (van Aalst et al., 2008).

Furthermore, there was a tendency amongst interviewees to blame their inability to change their approaches on donor funding or existing structures of working. However, almost all of the initiatives discussed came about owing to the initiative and foresight of individuals working within existing systems:

> *'we had just a particularly visionary environmental water engineer who just took it upon himself to get some funding and to do some research that became just bigger than* [our organisation] *in many ways because it was received so credibly. …they* [UNEP] *read this and said "oh my goodness, we understand completely the human interface between disasters, drought, conflict and water resources and climate change" because it was presented so well and so clearly in this publication and then of course he went over to head up UNEP.'* (Director – Disaster Management Team, INGO H)

There is, therefore, an implication that NGOs need to employ the right people: this individual not only had technical knowledge but also processed the particular 'visionary' qualities that meant he was able to convey this knowledge in an understandable manner. The above example also emphasises the problem of retaining staff with technical skills.

[17] Adviser – DRR (INGO E)

Generally the INGO interviewees appear not to be assessing hazards and risks at the natural system scale. The process of multi-hazard assessment discussed by interviewees primarily focused on the community scale, as it is driven by the need to understand the local context.

### 4.3.2 The process of (multi-)hazard assessment

In general, it appeared that the PHVCA process is more concerned with vulnerability, capacity and, particularly, generating action than it is with hazard assessment. Two interviewees commented on this as they emphasised the importance of not focusing on hazards[18]:

> *'I think* [the point] *was actually to go beyond the hazard data which obviously everyone likes to create which is nice and scientific and easy to define but even getting agreement in most countries on what the poverty indicators should be is really quite political.'* (Team Leader – CC, Research Institute B)

Only one participant[19] (although it was implied by three[20] others) questioned whether the emphasis on vulnerability had been at the expense of adequate hazard assessment:

> *'I would say, apart from in the Philippines and maybe Bangladesh, we've…had a few weaknesses…because we haven't focused enough on the hazards, particularly multi-hazard assessments'* (Adviser – Policy and Research, DRR, INGO D)

The first quotation emphasises the misplaced perception that hazard analysis is easy, which is in contrast to the challenges of assessing multi-hazards identified in Chapter 2. The quotation therefore implies a lack of appreciation for what multi-hazard assessments entail. Moreover, the first quotation points to a slight anti-science bias, which emerged subtly and, at times, more obviously during the Head Office interviews. During the interviews, there emerged a number of biases that influence the process of hazard assessment, which are discussed below.

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[18] Team Leader – Climate Change (Research Institute B); Policy Coordinator – DRR (INGO G)
[19] Adviser – DRR Policy and Research (INGO D)
[20] Adviser – Climate Change (INGO B); Adviser – Climate Change (INGO D); Director – DRR and Community Resilience (INGO I)

Most interviewees described similar community-based participatory methods for the purposes of data collection and analysis. Methods for identifying hazards over space and time include timelines, seasonal calendars, transect walks, hazard mapping and hazard prioritisation. The emphasis on facilitation in the process of hazard assessment emerged throughout the interview narratives:

> *'…you have to have very strong facilitation to make the link back to the hazard.'* (Director – DMT, INGO H)

When asked what information is important to include in the assessment of hazards, those who could answer noted hazard parameters including frequency, intensity and duration. In particular, one interviewee, whose organisation has taken a more hazard focused approach to assessment, noted a variety of parameters, however their hazard-focused approach did not resonate across the interviews:

> *'...in terms of characterisation, there are so much time elements...from the warning signs for warning speed of* [onset] *also frequency, period* <unclear> *these are all time element*[s] *– because this is where you can prepare for your contingency plan.'* (Adviser – DRR, INGO E)

Through the historical perspective of the community, multi-hazards can emerge, but subsequent analysis constitutes a series of individual hazard assessments with little regard for the interrelations between hazards:

> *'...So starting off with the hazard assessment and then going through the various steps in terms of understanding vulnerabilities to that hazard and then looking at another hazard and this sort of iterative process that would over time highlight what are the vulnerabilities that are fundamental to address regardless of whichever hazard we're focused upon in our analysis'* (DRR Consultant)

As noted above, the emphasis is upon identifying vulnerabilities common to more than one hazard. However, DRR Adviser for INGO E emphasised the need for solutions that are very hazard specific, rather than a description of generalities, but this very hazard focused approach to the PHVCAs was not representative of the rest of the interviewees.

The identified hazards are subsequently ranked through a prioritisation exercise. Interviewees noted that hazard prioritisation would tend to result in the consideration of the top three hazards, but that at times only the top hazard would be considered[21]. The quotation below exemplifies the constraints this imposes upon the analysis of multiple hazards since the organisation in question frame their assessment on the possibility of only five different hazards occurring and then focus on the top three, or the single most dominating threat as is perceived by the community:

> *'Well, we sort of ask about hazards in a few different ways, it's a bit of a triangulation but I think the most interesting one for prioritisation is the vulnerability matrix...we ask for you know five hazards and five most important resources and then they do the ranking and then we will ask, 'what are the three priority hazards out of those five?... So that's the key one, but then we also look at the hazard map, so if a hazard is coming up in all those different discussions, than it's clear that that's one of the bigger ones, even though that's not very scientific, it's very qualitative approach.'* (Adviser – CCA, INGO C)

Since the PHVCA process is solution driven, the emphasis is upon identifying the top hazard to address; although, in reality, it was noted that the selected hazard may also be driven by the assumptions or biases of the partner or project managers[22]. Section 4.2 elucidated institutional bias, including assumptions agencies make regarding the priority hazard and the decisions regarding where to implement projects. Furthermore, one interviewee noted that the outcome of the PHVCA may be influenced by the organisational remit of the implementing NGO:

> *'Nearly all organisations have a kind of organisational niche, something that they want to be known for and they think they do better…so…I really stress the need to sort of plan and differentiate between facilitating and brokering a process of community analysis…and not prejudicing…what action comes out of that.'* (Programme Policy Management Team Member, INGO F)

[21] Adviser – DRR (INGO H)
[22] Climate Change Policy Adviser (Development INGO)

Bias might also emerge from the individuals designing the toolkits (Section 4.2) as well as those facilitating the process, owing to their assumptions (and uncertainty) about different hazards:

> *'So it is also* [a] *very important tool for us but it's not just about climate change it is about environmental degradation, it is about disaster risk; but obviously mainly looking at disaster risk from a hydro-meteorological perspective rather than necessarily a seismic, because obviously prediction of seismic is quite difficult.'* (Research and Policy Officer, INGO H)

However, participants[23] also noted the difficulty of managing communities' expectations with regard to what concerns the NGO will be able to assist them in addressing; thus prioritising is a means of limiting these expectations.

The process of prioritisation is essentially based on the community's perception of the threat from different hazards, comparing characteristics such as frequency and intensity or sometimes utilising a vulnerability matrix or pair-wise ranking; although at times the prioritisation of hazard will just consist of a conversation with the community[24]. As noted by five[25] interviewees, the prioritisation is, consequently, largely qualitative, with two interviewees emphasising that it is not underpinned by science[26]:

> *'Generally people are happy with* [the method] *and we're clear, it's not scientific, it's consensus.'* (Adviser – Environmental Sustainability, INGO H)

The participant from Kenya (INGO C) said that feedback from partners indicated that they wanted more quantitative measures and they also criticised the tool they used because prioritisation of three hazards was too constricting. Furthermore, in environments where hazards might reoccur over different time periods, it becomes questionable whether these top

[23] Adviser – DRR (INGO B)
[24] The Climate Change Programme Adviser (INGO D) says that these are simply listed; the CCA Adviser (INGO C) emphasises that it is a very qualitative approach, based on what emerges from discussions with the community.
[25] CCA Adviser (INGO C); Kenya staff (INGO C); DRR Adviser (INGO E); CC Policy Adviser (Development INGO)
[26] Adviser – Environmental Sustainability (INGO H); Adviser – CCA (INGO C)

three hazards can be rigorously determined. Two interviewees[27] noted that because the process relies upon community knowledge it may be strongly influenced by the occurrence of the most recent event or seasonality of events[28]:

> '[earthquakes] *happen very, very rarely if at all. But it was extraordinary because the affect it had on the psyche of the people and in terms of what they … considered as the most sort of imminent hazards was absolutely identified as an earthquake in the months following that particular incident; whereas we're working with communities who are living on the banks of a river which floods all the time'* (Translator (formally in programme team) providing additional information as requested by Regional Programme Manager – DRR, INGO B)

Such a perception of risk poses a challenge to the objective identification and prioritisation of hazards, which is also challenging owing to differences in frequency of occurrence and the impact of different hazards:

> *'So essentially we do rank them but whether we rank them in a systematic way, I don't think we do. I am just thinking of the situation in Haiti now and we have obviously got an earthquake which is a rare event and yet the country is sort of afflicted every year by hurricanes so how do you balance your intervention.'* (Policy Coordinator – DRR, INGO G)

Compounding this is the challenge of managing the emerging multitude of non-extreme events faced by the community (the day-to-day hazards) that readily surface during the hazard assessment process[29]. Lastly, the community are not passive in their participation. The DRR Adviser at INGO B noted that, at times, a community may manipulate the process so as to ensure it serves what they want, which may not necessarily lead to a reduction in risk. Thus, in spite of the intentions of the developers, it appears that the design of toolkits, compounded by biases from organisations and individuals, hinders the application of a multi-hazard approach to PHVCA. However, it is important to note that the in-country interviewees placed less

[27] Regional Programme Manager – DRR (INGO B) and Policy and Research Adviser – DRR (INGO D)
[28] Policy and research adviser – DRR (INGO D)
[29] Project Manager – Livelihoods and Disaster Management (Development INGO)

emphasis on the tools and more upon the process of PHVCA, as similarly observed by Twigg and Bottomley (2011).

There was some acknowledgement of the limits of current approaches; Climate Change and Hunger Team Leader (INGO C) noted the need to develop a more methodological tool to ensure that hazards and vulnerabilities would not be missed, whilst four others[30] mentioned that improvements were needed in the field of multi-hazard assessment, particularly regarding concerns over unanticipated, emergent threats:

> *'I think in fairness this* [tool] *does keep the pages open, it does allow for genuine inclusion of every possible threat or hazard that the community might come up with. And we have committed to address that as far as possible, but I think we can do more, I don't know how, but I think we need to, not start from scratch, but we need to consider wider hazards, wider multiple hazards, and multiple threats that we might not expect. And that we might not even expect the community to come up with.'* (Team Leader – Climate Change and Hunger, INGO C)

It was apparent, however, that unknown future scenarios were largely considered a concern related to climate change and not other hazards. However, the three DRR in-country interviewees discussed climatic and geophysical hazards in more equal terms and did not appear to make the same distinctions between DRR and CCA as those at Head Office.

Given the emphasis upon integrated risk and, moreover the emphasis upon climate change, it appears that agencies are attempting to move towards a better understanding of the links between hazards, the environment (i.e. conditions that exacerbate risk), vulnerability and interventions. Such a shift in approach presents an opportunity for the interrelations between hazards to be more readily identified; however, whether this emerges within PHVCAs appears to rely heavily upon facilitation as illustrated in the example of the challenge of linking vulnerability and environmental degradation to an increased frequency of disasters:

[30] Adviser – Climate Change (INGO B); Policy and Research Adviser – DRR (INGO D); Team Leader – Climate Change and Hunger Team (INGO C); Director – DRR and Community Resilience (INGO I)

> *'…and an increased population has actually contributed to the increased land degradation and consequently more hazards, more flooding and landslides. So we might easily make that connection but often you will find that communities haven't made that connection and once that's made, and…they start seeing how they can reduce it,* [it] *is quite easy.'* (Adviser – DRR, INGO B)

In relying on facilitators to help communities make these connections, there is the implication that facilitators have sufficient knowledge and understanding to identify these connections themselves; yet discussion regarding secondary or interrelated hazards did not greatly emerge during the interviews. However, some acknowledgement of hazard interrelations emerged during interviews when participants mentioned earthquake and rainfall triggered landslides[31], *'secondary or tertiary hazards'*[32], the influence of climate change on hazards[33] and that there might be no one single cause[34] of a disaster. Consideration of the cascading effect of hazards was particularly apparent during the interviews with Philippine participants:

> *'…typhoon result to a multi-hazard: from typhoon of course we have rainfall, we have landslides, from landslides we have these flood the inundation of flash flood and from that another secondary or tertiary hazards will come there are other diseases after the disaster like we have this sickness related to diarrhoea…'* (Adviser – Climate Change and DRM programme, INGO G)

But, in spite of these interrelations being mentioned, it was unclear how these might be accounted for in the PHVCA process since interviewees discussed them in general terms:

> *'…we try and make sure that community does really view things, everything from a multi-hazard perspective. But…for example in North India in Behar they say it's floods, …and yet they are in* [the] *seismic floor zone and that's because nothing has happened in living memory of great significance and…the problem is…one really big earthquake… and you might get a re-alignment of the rivers and you might get a different set of flooding anyway, it might be that one hazard triggers another so …We try and make sure it is as multi-hazard orientated as possible.'* (Director, DMT, INGO H)

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[31] Adviser – Climate Change Programme (INGO D); Project Manager – Livelihoods and Disaster Management (Development INGO)
[32] Adviser – Climate Change and DRM Programme (INGO G, Philippines)
[33] Adviser – DRR (INGO E)
[34] Adviser – Climate Change Policy (Development INGO)

The above quotation also hints at the limits of community knowledge for multi-hazard assessments.

Given the emphasis on community knowledge for the purpose of identifying and prioritising hazards, historically, the PHVCA process has not been particularly successful at anticipating disasters:

> *'one of the weak links we saw with* [PHVCA] *was that it wasn't reviewing things, it wasn't reviewing the future enough and it was doing a lot of past historical assessment based on date test historically when we don't know, we are in un-chartered territory with a lot of these…climate variabilities.'* (Director – DMT, NGO H)

Therefore, an integral part of the PHVCA should include reviewing and updating the assessment at regular intervals.

### 4.3.3 Reviewing assessments: changing hazard profiles over time

Identifying multi-hazards is constrained by the extent and degree to which the community can reliably remember disasters, especially when specific data like frequency and impact are required. Two[35] respondents noted that the process of prioritisation was time dependent and often dominated by the most recent event and seasonality of events:

> *'We had one partner in Nicaragua which came up with a really nice chart. They actually had it on a timescale so they were prioritising not just, not just giving us a one off answer that actually this is the most important thing, they were saying well it depends on the time.'* (Adviser - Climate Change Programme, INGO D)

Reviewing and updating the hazard and risk profile of communities should be an essential component of the PHVCA process, owing to the fact that interviewees feel that PHVCAs are not particularly good at anticipating future risk[36]. However, the review of PHVCAs constituted the ideal rather than the norm and would, in reality, involve reviewing the interventions,

[35] Regional Programme Manager – DRR (INGO B); Adviser - Climate Change Programme (INGO D)
[36] Director – DMT (INGO H)

action plan and monitoring vulnerability, rather than reflecting upon any changes in the hazard profile:

> *'But I don't think that the actual assessment would be done again but it is a good point that if you are in a location where the hazards and risks are changing through climate change or anything else then perhaps the assessment should be repeated as well.'* (Adviser – DRR, INGO H)

However, reviewing hazards appeared to be more established amongst two of the in-country interviewees[37], owing to their emphasis upon the process of PHVCA (rather than tools). They emphasised that it will be continually updated (or at least monitored regularly) by the community:

> *'Tools are tools but we have to make the tools a living document to make it useful to affect change in the community,'* they then go on to say: *'…we do the risk assessment but once we implement the project there is a continuing evaluation because risk is variable, it's changing, people think that's right at the time but we do not know that there could be emerging hazards...'* (Adviser – Climate Change and DRM Programme, INGO G)

Six interviewees[38] mentioned baseline monitoring; however these often pertained to monitoring the project rather than the hazard profile. Moreover, the process of reviewing the hazard assessment appears to be informal rather than a prescribed component of the PHVCA process[39]. Part of the problem is reliance upon good, sustained, facilitation and that review involving the NGO is only possible within the duration of the project funding (which may be as short as a year), which is why the DRR Adviser for INGO B emphasised the need to instil this within the community. Moreover, institutional funding comes with a strict set of criteria for

[37] Regional Programme Manager – DRR (INGO B); Adviser – Climate Change and DRM Programme (INGO G)
[38] Adviser – DRR (INGO B); Team Leader – Climate Change and Hunger Team, Kenya country team (both INGO C); Policy and Research Adviser – DRR (INGO D); Adviser – CC Policy and Project Manager – Livelihoods and Disaster Management (both Development INGO)
[39] Project Manager – Livelihoods and Disaster Management (Development INGO)

monitoring and evaluation[40], focusing more upon changes in vulnerability and capacity owing to project activities rather than encouraging monitoring of the hazard profile.

In spite of these organisational constraints, the lack of review indicates a poor appreciation of the dynamic nature of hazards and risks in general, supported by the fact that the majority of interviewees only emphasised the concept of change in the context of a changing climate:

> *'I mean adaption is not a static state whereas* [PHVCA] *and DRR community based DRR tends to…result in plans that don't necessarily change so how do, how do communities learn on an iterative principle you know repeatedly understanding how their climate's changing and how do they take decisions basically, flexibly to sort of deal with that uncertainty.'* (Programme Policy Management Team Member – DRR, HD INGO F)

Although the perspective of a single conservation NGO is included in the study, it was observed that these organisations intrinsically adopt longer-time frames and larger geographical scales in their analyses:

> *'the conservation sector looks at projects from a very long time horizon, like our planning framework is like 20 to 50 years. And like really big scales, like we talked about earlier. You know they look at like satellite imagery and see how forest cover has changed over time, which is totally different than how humanitarian organisations work.'* (Team Leader – Climate Adaptation and DRR, Conservation NGO)

Given that conservation NGOs are addressing DRR, there is perhaps an opportunity for overlap. The Conservation NGO above produced a DRR training package for humanitarian NGOs, however it does not address how to conduct a multi-hazard assessment as the Conservation NGO representative stated that they assume humanitarian NGOs know how to implement these. The findings of this research have, however, challenged the adequacy of the multi-hazard assessments currently being employed by INGOS.

[40] Research and Policy Officer – DRR (INGO H)

### 4.3.4 Summary of multi-hazards in PHVCAs

Conceptually, toolkits are designed to incorporate more than one hazard. In reality, the approaches adopted and the current emphasis on climate change challenges the integrity of the claim to a multi-hazard approach. The PHVCA process lacks a systematic means of addressing hazard interrelations and is constrained by the temporal and spatial scales of analysis, which reflect the emphasis on community knowledge. The emphasis on this single information and knowledge source is discussed in the following section.

## 4.4 The role of science and community knowledge

Community knowledge was emphasised as the essential source of information for the PHVCA. According to in-country interviewees, the reliance on community knowledge is due to communities' extensive experience of hazards. Head Office participants particularly emphasised the role of community knowledge in empowering communities. Generally, however, all interviewees highly valued community members' awareness of their own situation and emphasised the ideal approach to PHVCA, which is to ensure that communities converse, prioritise and identify solutions to address risk free from the influence of the NGO:

> *'So what I'm saying is that communities, they know already their situation, they* [have] *their contacts, they have the solutions, sometimes we could bring our solutions but it's not probably appropriate so their solutions is to also cope by their culture and cope by their situation and sometimes we fail to see that'* (Adviser – DRR, INGO E)

Only one interviewee challenged the above view, suggesting that NGOs are in a unique position as outsiders to support the community in identifying solutions:

> *'…frequently the NGOs get so blinkered that we are…the voice of the people. Rubbish we are not the voice of the people at all. We are not and we never will be and we should recognise the advantageous position that we hold which is to be able to give that macro overview and saying, in light of that and in light of our knowledge of this changing context out here, the solution is not just to empower the community to find the solutions to its problems'* (Director – DRR and Community Resilience, INGO I)

This perspective emphasises the role INGOs might have in bringing external knowledge and expertise, for example hazards scientists, into the process of building community resilience.

A few interviewees identified limits of community knowledge, including the fact that it is constrained by communities' perceptions of hazards[41], influenced by the most recent disaster (noted in Section 4.3.2), that communities are more concerned with day to day risks[42] and the fact that communities do not know everything[43]. The greatest emphasis upon the limits of community knowledge emerged in the context of climate change, the concern being that community knowledge is becoming redundant in a changing climate[44]:

> *Climate change means hazards not predictable anymore – participatory processes can be useless – community were not knowing things.* (Director – Humanitarian Team, INGO A)

A number of participants noted that focus group discussions with the community are meant to be (but are not always[45]) supported by interviews with 'key informants' within the community. When asked whether these would include any outside expertise, participants gave the example of local government, other NGOs, civil society organisations or agricultural extension workers, owing to the fact that many of the programmes have a rural focus. Agricultural extension is, by the simplest definition, the provision of research and agricultural education to farmers and communities for a variety of purposes, including agricultural development, community resource development, group promotion and cooperative organisational development (Rivera et al., 2001). McCall and Peters-Guarin (2012) describe agricultural extension as the 'first doorkeeper' between external science and local knowledge, but it was

[41] Regional Programme Manager – DRR (INGO B)
[42] Policy Coordinator – DRR (INGO G)
[43] Director – DRR and Community Resilience (NGO 1); Adviser – CC Policy (Development NGO); Director - Disaster Management Team (INGO H; Adviser – Environmental Sustainability (INGO H)
[44] Adviser – CC Policy (Development INGO); Director – Humanitarian Team (INGO A); Team Leader – CC and Hunger Team (INGO C)
[45] Noted by Director – DRR and Community Resilience (INGO I)

apparent from the interviews that external expertise does not tend to extend to hazard scientists (*cf.* Twigg, 2004):

> *'It would usually be people within the community itself like the tutors, medical people, people in other NGOs, community leaders, government officials. So yeah, I mean I am not aware of a situation where they have gone and talked to hazard specialists in the university or something like that.'* (Adviser – DRR, INGO H)

Moreover, the information derived from these outside experts tended to be more for the purposes of supporting solutions and adaptation options, rather than for input into the hazard assessments.

As specifically noted by four interviewees, the NGO facilitators are perceived to have a role in providing information, owing to their perceived obligation to highlight threats to the community that '*they've just not had the opportunity to get informed about'* (Climate Change Policy Adviser, Development INGO). This assumes, however, that NGOs and facilitators have sufficient knowledge and access to relevant information to inform the community and it also contracts interviewees' claims that the community know the situation best.

Chapter 2 emphasised that the process of PHVCA is designed to incorporate secondary information, as supported by the following statement:

> *'In theory you should spend as much, if not more, time before you actually get to a community doing secondary data collection and understanding you know everything…on climate change and hazards, hazard profiling you should have all that information and really just be going through certain aspects with communities; and you know helping them understand, making that information accessible to them. But it's not done that often very, very well I'd say.'* (Programme Policy Management Team Member – DRR, INGO F)

One interviewee[46] emphasised that it is not up to the NGO to conduct *'volcanic'* or *'earthquake'* hazard assessments but that they would rely on ascertaining this information

[46] Project Manager – Livelihoods and Disaster Management (Development NGO)

from elsewhere. Four other interviewees[47] mentioned the use of secondary information, but it was apparent that the application of this information constitutes an ideal rather than a reality:

> *'I mean they might draw upon secondary data sources as well if there are climatic or scientific records for that area people should be making use of this as well but it's primarily based on the community's information.'* (Adviser – DRR, INGO H)

As indicated above, the utilisation of secondary information emerged primarily in the context of CCA[48]. The emphasis on 'internal' (community), rather than 'external', expertise and the limited incorporation of secondary data implies that science is not readily incorporated in the context of hazard assessments, but the following discussion explores this further.

### 4.4.1 Engagement and utilisation of science: the dominance of climate science

Although all interviewees valued science, its utilisation was discussed primarily in the context of CCA (even by DRR specialists), particularly in the case of Head Office participants. Two examples of engaging with climate scientists were shared. Firstly, the Kenyan representative (INGO C) described engagement with local climate scientists. However, the mismatch between the decadal scale of this information and the outlook of communities was noted (Walker et al., 2014):

> *'...we are not bringing the international, the meteorological prediction into the communities; to be perfectly honest I don't think it's served any purpose. You know what they're interested in is three weeks: "I got the seeds, I've tilled the land, we are ready to go, do I plant or not? Give me a three weeks forecast."'* (Team Leader – Climate Change and Hunger Team, INGO C)

The Climate Change Programme Adviser at INGO D discussed farmers making decisions based on climate science, noting that these have admittedly focused more upon seasonal forecasting. This practice was also noted by INGO B's Climate Change Adviser with regard to

[47] Adviser – CCA (INGO C); Adviser – DRR (INGO H); Project Manager – Livelihoods and Disaster Management (Development INGO)

[48] Programme Policy Management Team Member – DRR (INGO F)

their organisation’s experiences. In addition, three[49] interviewees noted that climate scientists need information from the local community.

Utilising climate science appeared more an exercise in raising awareness of climate change rather than utilising the data to inform assessments. This approach was in part due to the associated uncertainty of this data, but three interviewees [50] also perceived the application of climate science in this manner to be necessary:

> *‘...you are like: well the science isn’t really telling us enough, or you know it’s not really on a scale that’s useful enough to inform a decision making so...we wanted users to really make a point of reading what’s out there, even if it’s not a, you know, it’s not information that’s necessarily digestible or particularly useful at a community level, just to sort of familiarize themselves with the quote unquote science is saying about climate change in Sahel for example. Maybe the jury’s out and that’s kind of frustrating but it’s still good to know that the jury’s out, you know.’* (Senior Researcher – Climate Change, Research Institute B)

In contrast, another three[51] interviewees disputed the use of very general information like that described above, emphasising the need for precise information that is useful to communities for the purpose of planning. In fact, the Climate Change Programme Adviser at the same organisation (INGO D) stated that most of the plans that they have seen are not informed by a climate analysis or a PHVCA of any kind.

Opinion was mixed as to whether communities would directly utilise science. One respondent noted that the community do not need ‘figures’ they just need to know whether or not they can plant crops; however two respondents disputed this perception by sharing examples of farmers and communities who understand climate science and make decisions based on an

[49] Programme Staff – CCA (INGO C, Kenya) gave the example of community monitored rainfall; Policy Coordinator – DRR (INGO G); Adviser – Environmental Sustainability (INGO H)
[50] Adviser – Climate Change Programme (INGO D); Kenyan representative (INGO C); Senior Researcher – Climate Change (Research Institute B)
[51] Policy Coordinator – DRR (INGO G); Policy Adviser – Climate Change (Development INGO); Project Manager – Livelihoods and Disaster Management (Development INGO)

understanding of the uncertainty[52]. In the context of integrating science, all but one interviewee emphasised that the process should begin with the community's knowledge.

In the context of DRR, INGO D's DRR Policy and Research Adviser noted that their in-country partners had demonstrated varying success in integrating science and multi-hazards into their programmes:

> *'it was very much again different in each country, and very much down to the program office…in the Philippines…she was just so excellent and well-connected…that she managed to really bring this kind of scientific multi hazard quite rigorous assessment methods and linked those and integrated those with the findings from the community assessments…*[in Malawi] *it was definitely not multi-hazard, very much focused just on drought, and …they didn't really* [discuss the Met Office data with the communities]*, but instead focused on community level assessments and gaps with the outcome that actually a lot of the DRR work that was being done there was a continuation of the same old same old….'* (Policy and Research Adviser – DRR, INGO D)

Furthermore, during the interviews with in-country representatives, science emerged much more in the context of DRR and, without prompting, during the interview with the DRR Adviser (INGO D):

> *'– we need to triangulate: well this is the perception of people on hazards, we also bring in scientists in the area to have our evidence, to have our facts more scientific. '* (Adviser – Climate Change and DRM Programme, INGO G)

One Head Office interviewee and another in-country participant[53] shared anecdotes of the incorporation of scientific knowledge and expertise in the context of hazard assessments, specifically geological surveys that identified previously unknown landslide risk. These examples reflected the initiative of individuals and organisations in-country, rather than a sector-wide recognition of the need to engage with scientific experts for the purposes of hazard assessment:

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[52] Adviser – Climate Change Programme (INGO D); Adviser – Climate Change Adaptation (INGO C); Project Manager – Livelihoods and Disaster Management (Development INGO)

[53] Policy and Research Adviser – DRR (INGO D); Adviser – CC and DRM Programme (INGO G)

> *'Often, the links are sometimes not so clear at first... they* [partners] *were saying that their DRR teams are quite science heavy, in that they will have a geologist…so they are quite 'techy'. And they said that the interesting thing about that is the PRA approach is fine because you need to have that to ensure that the community is confident in the whole sort of approach, and they feel it is addressing their priorities. But there is some* [hazards] *that they don't know about. So for instance they frequently uncovered, through geological surveys, risks (particularly landslide risks) that were completely unknown…sitting right above a village…but through this very scientific surveying approach they have uncovered something that people should be aware of.'* (Policy and Research Adviser – DRR, INGO D)

The above quotation emphasises the limits of community knowledge and also indicates the interviewee's initial hesitancy regarding the application of science, indicative of reluctance shared by other interviewees. One interviewee felt that it would not be necessary to *'bring a scientist down to the grass roots to actually participate in the* [PHVCA][54]*'.* Additionally, the difficulty for organisations working with partners (and to some extent autonomous regional offices) is that it is up to the partner to decide whether or not they engage with external expertise, in spite of recommendations from the INGO:

> *'...my experience* [of] *introducing different partners to different organisations like the local UNDP office* [is] *that they weren't necessarily connected with and going into the district level of governments and government offices...my sort of feeling was I think that…the partners I was working alongside, they were very much doing their thing...'* (DRR Consultant)

Thus, there was concern (amongst two Head Office interviewees in particular) as to how the process of engaging with scientists would be sustained, with one questioning how communities would be able to, for example, pay for a '*highly trained geologist'*[55]. At the same time, three interviewees acknowledged that they need to improve their engagement with all the necessary science since 'participatory rural appraisal' (PRA) limits expertise to livelihoods, agriculture and climate advice.

[54] Director of the Disaster Manager Team (INGO H)
[55] Adviser – Climate Change Programme (INGO D)

### 4.4.2 Perceived and real barriers to integrating science with community knowledge

All interviewees seemed to value the utilisation of science, but it emerged there were a number of perceived and real barriers hindering its integration. The emphasis on climate science meant that interviewees fixated on the problems associated with this type of science. Scale, in terms of both poor local data resolution and long-term projections (beyond the length of community concerns and NGO project planning) were deemed a blockade to the application of climate science. However, there were barriers identified that apply to science more generally.

Fundamentally, respondents felt that the utilisation of science necessitates simple, local analyses that are well communicated to those whom require them. Communication[56], access, a lack of local scale information[57] and scientific uncertainty were all quoted as hindering the integration of (climate) science with community knowledge. However, the most revealing barrier that emerged from the analysis was, however, the uncertainty at both an organisational and individual level as to how natural science can be applied and what science is of use. Underlying the barriers is a series of perceptions and assumptions, including preconceived ideas about science and scientists and the tendency amongst Head Office interviewees to couch science in terms of climate change. This was partly fuelled by the perception that DRR is a much less scientific discipline than CCA:

> *'So* [DRR]'s *very much more an applied practical discipline and it's not particularly academically rigorous or scientific necessarily; whereas adaptation has really emerged from you know from science, from social science and meteorology…'* (Programme Policy Management Team Member, INGO F)

[56] Team Leader – CC and Hunger Team (INGO C)
[57] Network Coordinator (Advocacy INGO); Policy Coordinator – DRR (INGO G)

What is implied is a relatively poor acknowledgment of the real value of science in hazard assessment, in other words the existing knowledge that is arguably easier to utilise than very uncertain climate science:

> *'whilst there was much emphasis on climate change science the fact* [is] *that most of its utilisation is in the form of techniques which were already available, such as seasonal forecasting, and that perhaps existing science could be more readily utilised (rather than new research).'* (Director – DMT, INGO H)

In general – and specifically noted by the DRR Regional Programme Manager (HD INGO B), the Climate Change Team Leader (Research Institute A) and the Director of DMT (HD INGO H) – there was the perception amongst the study A interviews that science has to become more engaged in the social elements of disasters, be specific to local settings and become more understandable. Head Office NGOs emphasised an 'action-learning'[58] model of research (*cf.* Mercer, 2012) and one respondent questioned how academic discourse could be integrated with work so focused on the essential elements between life and death[59]. This was also reflected by the fact that historically it has been up to the NGO to approach scientists[60]:

> *'It hasn't come from universities to the social or the experience in field, their proposal comes from us to them. And the process is that you need to convince them.'* (DRR Regional Programme Manager, INGO B)

However, although not a reflexive stance taken by the majority of the interviewees, two interviewees observed that the problem may also lie within NGOs themselves since they are primarily comprised of social scientists[61]:

> *'I was very anti-science…I made a conscious decision early on that actually it wasn't about science, social science was the only way forward; but it is very interesting, NGOs are basically made up of social scientists, and it is incredibly how that whole social science mentality pervades.'* (Adviser – DRR, INGO B)

[58] DRR Consultant; Adviser – DRR (INGO E); Network Coordinator – Advocacy INGO; Adviser – Environmental Sustainability (INGO H)
[59] Director – Humanitarian Team (INGO A)
[60] Regional Programme Manager – DRR (INGO B); Adviser – Policy and Research and Adviser – Climate Change Programme (both INGO D); Director – DMT (INGO H)
[61] Adviser – DRR (INGO B); Adviser – CCA (INGO C)

The above interviewee also suggested that the pervasiveness of social scientists within NGOs means that they are not in a position to know what questions they should be asking of scientists. This is also reflected by the underlying uncertainty within NGOs regarding how to use science:

> *'we as NGOs I think we're struggling with that* [*'the science thing'*] *– the simpler the better I say and it's to do with arable land reduction, water table reduction, food crop yields – that's what they* [communities] *get.'* (Team Leader – Climate Change and Hunger, INGO C)

This limited capacity was recognised by the CC and DRM Programme Adviser (INGO G) from the Philippines who stated that:

> *'we are not scientists…*[so] *why not invite geologists from the…Geoscience and Mines Bureau in the Philippines to come.'* (Adviser - CC and DRM Programme Adviser, INGO G)

However, there was also a degree of reluctance amongst some interviewees to engage with scientists[62] owing to concern over the legitimacy of the participatory process of hazard assessment and the need to maintain emphasis on people's vulnerabilities and capacities for action[63]. The very participatory approach is juxtaposed against the perceived 'positivist'[64] mentality of science:

> *'the danger that we see is…where technical aspects become more important…, or hazard assessments could become suddenly more important, or suddenly prioritised also in terms of funding over analysis of social political economic dynamics that underpin peoples vulnerability….'* (Policy and research Adviser – DRR, INGO D)

Furthermore, as noted by two interviewees[65], the process of engagement may not always run smoothly:

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[62] E.g. Climate Change Team Leader (Research Institute A)
[63] Regional Programme Manager – DRR (INGO B); Adviser – DRR Policy and Research; Team Leader – CC (Research Institute A); Director – DMT (INGO H)
[64] Team Leader – CC (Research Institute A)
[65] Adviser – Climate Change Adaptation (INGO C); Senior Researcher – CC (Research Institute B)

*'I have seen it go both ways, where you know, sort of the use and the translation of science in communicating an environmental threat and to explain changes at the community level has been really powerful and very empowering, but I have also seen the opposite thing. And so I guess it's really the role of the person or the medium used to sort of do that translation and that communication, that's just essential.'* (Senior Researcher – Climate Change, Research Institute B)

This quotation emphasises the need for a broker of scientific information. However the above findings question whether NGOs are able to fulfil this communication role.

### 4.4.3 The reality of 'internal' and 'external' information and expertise in PHVCA

In general, it appears that the knowledge used for hazard assessment is essentially derived from the community, supported when possible by agricultural extension workers and local government however their input is mostly in terms of building capacity in order to design and deliver projects, rather than for the purposes of rigorous assessments of multi-hazards. Science is valued but tends to be conceptualised and utilised within the context of climate change. Many real and perceived barriers appear to prevent the greater utilisation of science, which is piecemeal in terms of CCA but almost non-existent in the context of DRR. NGOs have a role in facilitating the engagement of external advice and in the provision of information, however there appears a general lack of acknowledgement of the limited capacity of NGO facilitators (largely social scientists) to provide the necessary information for the purposes of (multi-)hazard assessments.

## 4.5 Summary

The findings have highlighted certain characteristics of INGO approaches to multi-hazard assessments. From the limited sample of in-country interviewees, the findings suggest that the reality of implementation may be quite different from the experiences and assumptions of those at Head Office level. The three in-country DRR representatives tended to be less concerned with development trends (i.e. 'DRR' and 'CCA') and toolkits and more focused on the process of PHVCA and, especially amongst the Filipino participants, the consideration of multi-hazards and the incorporation of scientific information to this end. However, taking the study as a whole, the analysis has resulted in three main findings:

(1) Agencies are attempting to assess more than one hazard, but are largely not adopting a multi-hazard approach that accounts for all natural hazards in a given place and their interrelations. The failure to adopt a true multi-hazard approach is owing to constraints upon the process of assessment, including whether it adopts a CCA or DRR lens, the utilisation of mostly community knowledge, the reliance upon good facilitation and, therefore, facilitators' and communities' capacities to identify multi-hazards and their interrelations.

(2) Incorporating multi-hazards is constrained by the fact that hazard assessments are limited to the community scale and are largely static and therefore might not account for distal hazardous processes that could affect the community or changing hazard profiles over time.

(3) Agencies are generally not adopting science for the purpose of multi-hazard assessment and, where science is used, it is generally in terms of climate change.

Given the divergence of opinions between Head Office and in-country representatives, the observations above were compared with the results of interviews with local and international NGOs in the Philippines. The results are discussed in the following chapter.

# Chapter 5: NGO hazard assessments in the Philippines

Chapter 5 compares the three main findings from the analysis of the interviews in Chapter 4 with the findings from the Philippines. Interviewees in Study A suggested that every implementation context is different; as such, the findings from the Philippines are understood as being useful for general understanding of hazard assessments but also grounded in the context of that country. Section 4.3 begins with a background to the interviewees, before comparing the findings of this analysis with the observations from Study A.

## 5.1 Background to interviewees, their organisations and DRR and CCA history

Table 5.1 outlines the participants interviewed, including some background with regard to their role and organisation. The agencies had similar histories with DRR and CCA; most had begun implementing DRR projects around 2006. Local NGO Ph3 had only conducted PHVCAs within the last 6 months (April – September 2010). Interestingly, during the interviews with the two local NGOs (Ph 1 and Ph 2), it transpired that their communities had been greatly affected by a typhoon (Reming) in November 2006. As a consequence of this disaster, the affected NGOs had begun to focus on addressing DRR:

> *'…*[our] *DRR work…started shaping up in 2004 it is introduced by one of staff of HD INGO D…*[he] *also introduced us the DRR and…introduced also to us the use of* [PHVCA] *tools but…DRR is already introduced by* [local gov. official] *to us but…we don't have any interest because during this time we focus on disaster relief. We started to shake up the DRR perspective in office started in 2004 but 2006 (after Reming), become now clear picture of what is DRR to us.'* (Point Person – DRR and Community-based DRR Programme, Local NGO Ph2)

Similarly, Local NGO Ph3 interviewees also described being introduced to DRR by their INGO partner but indicated that they had already been thinking along these lines. The local agencies did not tend to have an extensive disaster risk management background; they may have been involved in disaster relief (e.g. Local NGO Ph2), but vary in their organisational remits (see Table 5.1). DRR Project Officer (Local NGO Ph3) said that they were trying to move towards addressing all their work through a *'DRR lens'*.

Climate change was not deemed a new phenomenon, with interviewees stating that they began discussing it several years ago. The concepts are differentiated, but it was surprising to discern a lack of emphasis on CCA compared with DRR as might have been expected, given this emphasis amongst the interviewees in Study A. In terms of implementation, the majority did not appear to draw a major distinction between CCA and their implementation of community-based DRR activities, and appeared to be addressing climate change in terms of its impact on disasters. However the Executive Director of Local NGO Ph1 perceived CCA to require a different approach:

> *'For us, the risk reduction measures are those strategies, activities or mechanisms that community are doing in order to… – not adapt – in order to phase, or to handle these adverse shocks no? that are coming but we're seeing that…sometimes this kind of actions strategies that we're doing are not necessarily an adaptation work, but it's just, maybe it's a tactical or a temporal action for community to respond or to bounce back easier into different shocks; but not necessarily yet an adaptation.'* (Executive Director, Local NGO Ph1)

Climate change also emerged as a discussion point for observed hazard and environmental changes during the Philippines interviews:

> *'If go to community…the people have own definition of* [climate change] *because time changes according to them. Noticeably hazard events are becoming more frequent. This Mayon volcano used to erupt every 10 years – but it was altered recently: it erupts maybe in the span of two to three years. Rains and floodings are now more frequent and just very abrupt unlike before. That's what we learn from the community people and also us observe as a native of this place. This hazard typhoon…and others becoming more frequent, and the magnitude of destructions becoming wider – very*

*intense. Before we don't experience this hot weather, all across the Philippines.'* (Regional Programme Manager, Development INGO Ph)

However there was also more of an awareness compared with Head Office interviewees (Study A) of the wider range of natural and human systems that could be causing the observed change. One interviewee[1] noted that climate change is *'quite loosely'* used to explain different changes, sharing the example of an area predicted to experience climate change driven drought which (along with flooding) is a *'past and future hazard'*. In this interviewee's opinion, DRR and CCA are *'all the same'* and *'difficult to prioritise* [as they] *all lead to disasters.'*

The comparative lack of emphasis on CCA compared with the findings from Study A may be indicative of the lag mentioned during Study A between changes at the international policy level and implementation at the practical level[2]. Indeed, the NGOs interviewed were still getting to grips with CCA and its implications for their work.

In the following section, the three main findings from Study A are rephrased as questions in order to compare them with the analysis of the Philippines interviews. As the following discussion will demonstrate, there were similarities between Studies A and B, but their greatest divergence was with regard to the appreciation of multi-hazards and the value and integration of science. Participants did not tend to refer to specific toolkits but adopted very similar techniques of hazard and vulnerability assessment to those described during the UK interviews, drawing on hazard mapping, timelines and prioritisation methods.

Interviewees emphasised the process, rather than a rigid set of instructions (tools). However, whilst developers of toolkits in Study A emphasised that tools are not prescriptive and that users are encouraged to adapt the tool based on the situation on the ground, these ideas may not migrate to those (local partners) implementing toolkits:

[1] Senior Programme Officer 1 (INGO Ph2)
[2] Director of the Disaster Management Team (INGO H; Study A)

> *'we would like to use simpler tools but if we can't help it then we have to* [use it] *because it's really part of the module but we would find ways to make it simpler and more understandable for community because honestly communities are not well adjusted to different tools used by local workers and local NGO workers – they just think of how they would earn more and how they would run the family.'* (Project Officer – DRR, Local NGO Ph3)

The implication is that, even if the NGO or the community find a component of the PHVCA toolkit difficult to implement, they must still use it because it is part of the defined process, thus countering the assumptions of developers in Study A that toolkits are used in a flexible manner. However, interviewees tended to emphasise the process of PHVCA more than the tools and those interviewees who commented on tools noted the need to adapt the tool based on the situation on the ground. However, the DRR Project Officer and Programme staff at Local NGO Ph3 felt that their experience of continually having to adapt tools and augment them with additional tools (driven by management) was at the expense of their actual understanding of the PHVCA process. The DRR Project Officer also noted that NGOs have a tendency to overly focus on the tools:

> *'I think NGOs have a knack of trying to get every available tool there is and confusing ourselves on what tool to use instead of focusing on one effective tool, efficient, simple tool – no way can we get every tool there is, try to integrate them and end up with complicated integrated tool – one problem of NGOs.'* (Project Officer – DRR, Local NGO Ph3)

What was particularly insightful was that the interviewees from the Local NGO Ph3 included both project and programme staff (those implementing) and the executive director, the latter being less critical of tools than the project and programme staff. The last quotation also raises the question as to whether NGOs put too much faith in toolkits and do not invest enough in facilitation. In the context of multi-hazards and the utilisation of science, it also suggests that creating or adapting tools might not be the means of integrating these approaches as it may only drive further confusion.

Table 5.1 Participants in Study B. Shaded participants did not contribute to the interview in the main. HD INGO represents Humanitarian and Development International NGO.

| Organisation | Operations | History of Engagement | | Respondent | Date of interview | Location of interview | Interview recorded (Y/N) |
|---|---|---|---|---|---|---|---|
| | | DRR | CCA | | | | |
| ***(HD) INGO Ph1 (Country Office)*** | Direct and local partners | 2007 | (*'at programme level do not have integrated CCA'*) | ***WASH DRR coordinator*** | 17/09/2010 | Makati City, Metro Manila | Y |
| ***(HD) INGO Ph2 (Country Office)*** | Local partners (Country office of HD INGO D from Study A – see table 4.1)) | (~1980s) 2006/2007 pilot community-based DRR programme | [Did not specify] | ***Senior Programme Officer 1*** | 17/09/2010 | Quezon City, Metro Manila | N |
| | | | | ***Senior Programme Officer 2*** | 17/09/2010 | Quezon City, Metro Manila | N |
| ***Local NGO Ph1 (livelihoods, development)*** (partner of INGO Ph2) | Direct (partnership with HD INGO Ph2) | 2006 | 2007 | ***Executive Director*** | 11/09/2010 | Legazpi City, Albay | Y |
| ***Local NGO Ph2 (relief and development, community organisation)*** (partner of INGO Ph2) | Direct (partnership with HD INGO Ph2) | 2004 (after 2006 *'became clear what is DRR to us'*) | 2007 (some discussion in 2006) | ***Point person - community-based DRR programme*** | 12/09/2010 | Legazpi City, Albay | Y (combined interview with participant below; this interviewee did the majority of the talking) |
| | | | | ***Community organiser – community-based DRR programme*** | 12/09/2010 | Legazpi City, Albay | Y |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Local NGO Ph3 (development, environmental)*** | Direct | 2009 | (2008 discussion on climate change) | ***Project Officer - DRR*** | 24/09/2010 | Osamiz, Misamis Occidental, Mindanao | Y |
| | | | | ***Programme staff – DRR*** | 25/09/2010 | Osamiz, Misamis Occidental, Mindanao | Y |
| | | | | ***Executive Director*** | 27/09/2010 | Osamiz, Misamis Occidental, Mindanao | Y |
| ***Development INGO Ph (Country Office)*** | Partner | [Did not specify] | [Did not specify] | ***Regional Programme Manager – Central Philippines*** | 15/09/2010 | Legazpi City, Albay | Y (combined interview with participant below; this interviewee did the majority of the talking) |
| | | | | ***Programme Officer*** | 15/09/2010 | Legazpi City, Albay | |
| ***Humanitarian INGO Ph (Country Office)*** | Direct (and volunteers) | [Did not specify] (2008 project on strengthening community preparedness) | 2008 | ***Head – Disaster Management Services*** | 10/09/2010 | Manila, Metro Manila | Y |

## 5.2 Comparison of findings from studies A and B

**(1) Are agencies looking at more than one hazard, but largely not adopting a multi-hazard approach that accounts for all natural hazards in a given place and their interrelations?**

All interviewees emphasised the multi-hazardous nature of the Philippines. Only one interviewee (below) stated that they deliberately focused on one hazard during the PHVCA process, which appears embedded in their perception that communities are of limited capacity to address more than one hazard, coupled with the fact that this organisation appeared relatively new to community-based DRR:

> *'because for them* [the community] it *is very complicated – we started prioritising first for typhoons'* (Regional Programme Manager, Development INGO Ph)

The NGOs referred to the hazard profiles of the areas within which they work as 'multi-hazard' and were focusing on natural and increasingly human induced hazards (e.g. INGO Ph2), with those working in Mindanao addressing DRR in the context of conflict. There was, however, an emphasis on weather related phenomena (typhoons, flooding, mudslides and drought; more frequent hazards) in spite of the fact that the local NGOs were also based in seismically prone areas.

Similar methods to those discussed by Head Office (Study A) participants were adopted for assessing multi-hazards:

> *'Timelining can capture multi-hazards, in the story you will remember all those events happening – sometimes it's rare that communities have only one hazard. It's mostly one or two or three hazards.'* (DRR Programme staff, Local NGO Ph3)

One interviewee[3] said that hazards would be considered only as far back as the last ten years noting that this was a decision shared by their academic partner. Such a time-frame, however, does not capture the incidence of less frequent hazards such as strong earthquakes or high-

[3] DRR Point Person (Local NGO Ph2)

impact volcanic events. In contrast, the Regional Programme Manager (Development INGO Ph) remarked on the fact that the community can remember events from 50 years ago, although this interviewee had particularly strong faith in community knowledge.

The process of prioritising hazards was described as comparing two parameters, for example, magnitude, duration and/or frequency (e.g. pairwise ranking[4]):

> *'They rank the most frequent hazard that occur in their community so base from that usually do from 1, 2, 3.'* (Point Person – DRR, Local NGO Ph2)

One interviewee also suggested that urgency is also a factor[5], which is interpreted as the urgency to address the hazard. Similar to the UK-based interviews, standard practice is to focus on the top one to three hazards, however in reality it might be that focus is solely upon the top hazard. During the Regional Exchange Workshop, it was observed that one community considered only the number one hazard based on severity, frequency and duration. Prioritisation is also heavily influenced by the community and NGOs' capacity to address the identified issues:

> *'I suppose for communities they prioritise hazards to respond to – it's enormous if they want to respond to three tops hazards (for example) it will be very costly to the village, the local government also; small income small districts and municipalities.'* (Executive Director, Local NGO Ph1)

Similar to the UK interviews, the assessment of 'multi-hazards' appeared to encompass a collection of individual, hazard specific, assessments. Only two interviewees[6] described addressing multi-hazards by identifying common vulnerabilities across hazards (observed in Study A) and, subsequently, building capacities that minimise these vulnerabilities:

> *'if perennially hit by typhoon and if you are already prepared, chances are you are already prepared to other hazards as well. So it's the linking…'* (Head – Disaster Management Services, Humanitarian INGO Ph Country Office)

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[4] DRR Project Officer (Local NGO Ph3)
[5] Executive Director (Local NGO Ph3)
[6] Head – DMS (Humanitarian INGO); Project Officer – DRR (Local NGO Ph3)

There appeared to be a greater general appreciation of the interrelatedness of hazards and disaster events in terms of secondary hazards, particularly landslides and lahars, amongst Philippine interviewees compared with the Head Office (Study A) interviewees. In terms of applying this appreciation to multi-hazard assessments, only one interviewee[7] made specific reference to the analysis of interrelations between hazards. However, their admission of adopting this approach may have been influenced by their prior attendance at a multi-hazards presentation given by the researcher; as such, multi-hazard assessments may not be truly carried out. Their strategy involves looking at common vulnerabilities and strategies to address these hazards, rather than the anticipation of these interrelated disasters:

> *'we did the comparative analysis of the hazard and we were able to look into interrelatedness; some of the hazards are really the offshoot or the result of this hazard and some of the hazards contribute to the formation of this type of hazard which is what you* [the researcher] *exampled in* [Regional Exchange Workshop]: *volcanoes and landslide, heavy rains and landslide and flash flood as well – when managed to look at the inter-relatedness of hazards we also managed to look into the inter-relatedness of the causes and also the impact the interrelatedness of impacts: more simple to narrow down strategies on how to address hazards because once a community thought of one strategy to address one hazard (if related to another hazard, it minimises the risk of the community to the other hazards); it's like two birds with one stone.'* (Project Officer – DRR, Local NGO Ph3)

This interviewee noted that there is *'no specific'* tool for identifying hazard interrelations because the information would emerge from the focus group discussion, but that without good facilitation communities may struggle to make these links. Indeed, as noted during Study A[8], communities were also perceived to require assistance in order to analyse information and make connections between hazards:

> *'That's why it's important to process it – you stay with community, you have to guide them – they have other prevailing needs as well that they can't assimilate to hazards they face...'* (Head of Disaster Risk Management, Humanitarian INGO Ph)

[7] Project Officer – DRR (Local NGO Ph3)
[8] Adviser – DRR (INGO B); Adviser – DRR (INGO E)

One participant emphasised that communities find the process of assessment very mentally challenging[9] and another[10] emphasised that this process needs to be 'internalised' within NGOs and communities, without which it will not be fully understood nor sustained; this extended to the use of science[11].

In comparison to the Head Office interviews, it would appear that hazards are similarly analysed independently by NGOs in the Philippines, but that there is greater understanding, appreciation and dialogue with regard to the interrelations between hazards. However, there still lacks a systematic approach to the assessment of hazard interrelations. Whether multi-hazard assessments are similarly constrained by limited scales of analysis and sole reliance upon community knowledge is explored in the next two sections.

**(2) Is the incorporation of multi-hazards in assessments constrained by the fact that hazard assessments are limited to the community scale and are largely static?**

The section addresses both spatial and temporal scales of hazard assessment. The findings were generally similar to the UK interviews in the sense that the primary focus is community (barangay) level assessment, with interviewees emphasising the need for local level hazard and vulnerability information.

INGO Ph2 Country Office, through fairly advanced engagement with scientists, were involved in the commissioning of much larger assessments, for example the risk assessments for lahars and typhoons for the province Albay (see MO-UP NIGS, 2009, and Chapter 8). Through their partnership with a research institute, INGO Ph2 Country Office has demonstrated that hazard profiles change depending on the resolution of mapping and thus they advocate the need for barangay scale hazard assessments. The Humanitarian INGO prioritised areas to work based upon the multi-hazard maps produced by the government (the READY project). The READY

[9] Executive Director (Local NGO Ph1)
[10] Programme Staff – DRR (Local NGO Ph3)
[11] Point Person – DRR (Local NGO Ph1; follow-up meeting after formal interview)

project was the result of a realisation amongst government agencies of the fact that the government wanted to standardise and consolidate their approach to hazard mapping:

> *'in the Philippines they don't have multi-hazard mapping, they have independent maps, for example landslide maps, because the organisations responsible for each are under different departments so they do not work together. But now they are trying with...the READY project'* (WASH DRR Coordinator, INGO P1)

However, these maps represent the mapping of discrete independently assessed hazards; therefore the project does not account for coincidentally occurring or cascading hazards, except in their differentiation of earthquake and rainfall triggered landslides. Moreover, these maps do not appear to reflect a return period for the hazards being mapped (see PHIVOLCS, 2014).

A comment from one local NGO interviewee implied that the implementation of larger hazard assessments can be facilitated by networks and collaborations with research institutes:

> *'We do not have capacity to* [do] *a larger scale so we have to do it at community and as a matter of fact in that community we do it in the Purok. But we are member of a network, take for example the Manila Observatory they can do wider focus of hazard assessment - rapid assessment – we can assist them, we are here we can assist you, accompany you to the area for conduct ground truthing or something – GPS you use or something.'* (Point Person – DRR, Local NGO Ph2)

The above quotation indicates that communities and NGOs have a role through communities' provision of the local context and NGOs facilitation in 'ground-truthing' the data. However, another interviewee[12] noted that scientists do not always ground truth their analysis, which is perhaps an area of engagement NGOs can encourage. Moreover, in spite of some discussion regarding larger scales of analysis, it was apparent that concern lies with ensuring detailed analysis at the local level takes place:

> *'We avoid the very general – 'livelihoods', but specifically farmers: what do you need? What will happen to the farmers when this flood as high as one or two metres, what*

[12] WASH DRR Coordinator (INGO Ph1)

> *will happen to you, to your houses, to your plants, to your livestocks? Those are being… put in detail per hazard in the community.'* (Executive Director, Local NGO Ph3)

Senior Programme Officer 1 INGO Ph2 noted the need to account for what is occurring upstream and downstream of communities (thus adopting a greater spatial perspective), whilst for four agencies[13] a more holistic perspective of risk has come about through their interest in water basin management, their current work in land use management and their concern with climate change:

> *'...there is a lot of logging or deforestation going;...ask...people to have an agreement with* [local government units] *and the community to say: okay, listen we want to support you to increase the water supply, access to clean water, but [you] have to protect or plant in the watershed areas around a number of trees for example; so you are just linking both – the climate change and the development and try to reduc*[e] *landslides; it's a holistic approach but we are going to pilot that one in Mindanao in a project we are starting just now.'* (WASH DRR Coordinator, INGO Ph1)

However, the extent to which the appreciation of wider natural systems leads to a more comprehensive analysis of multi-hazards is questionable since most interviewees only referred to flooding and (to some extent) landslide hazard in this context. However, the influence of environmental degradation on hazards emerged during the interviews in terms of their impact upon the multi-hazard profile of communities, especially noted by staff from Local NGO Ph3 owing to their existing work on the impacts of mining and deforestation.

***Temporal analytical scales***

Amongst interviews, the general emphasis appeared to be on the most frequent hazards. One interviewee emphasised the problem of convincing the community of hazards they are yet to

[13] INGO Ph1; INGO Ph2 ; Local NGO Ph2; Local NGO Ph3

experience[14]. Most interviewees, however, said that they and the community are aware of changes in the hazards, placing particular emphasis upon changing climate hazards.

Three[15] interviewees observed the dynamic nature of hazard and risk and others implied this by mentioning that there is a need to review hazard profiles because hazards change:

> *'hazard mapping should be periodically reviewed after every hazard and major disaster it should be reviewed – we can facilitate that but we are also confident that some but not all of partners can already do that. There are number of community partners that can do their own review and then* rehancement *or adjustment of contingency plan or hazard assessment work.'* (Executive Director, Local NGO Ph1)

When discussed, the responsibility for repeating assessments was perceived to lie with the community[16] and or the local government unit (LGU)[17], with some in-kind support from the NGO if possible:

> *'That is part of their contract is to do update the map – the data and the hazard map – even* [Local NGO Ph2] *do not visit them because our programme is already finished. But if you have all responsibility in the barangay council they have the responsibility to update – but as* [Local NGO Ph2] *we can visit them. Because the high risk areas text us if they have the questions; last year they recommended trainings but we do not have any more funds – but we can help them to network with other agencies.'* (Point Person – DRR, Local NGO Ph2)

Two interviewees[18] perceived that by mainstreaming DRR and CCA in government development plans, the review of local planning would ensure review of the hazard profile[19]. However, the interviewees commented on the lack of capacity for DRR within LGUs and that it is unusual for NGOs and government to work together.

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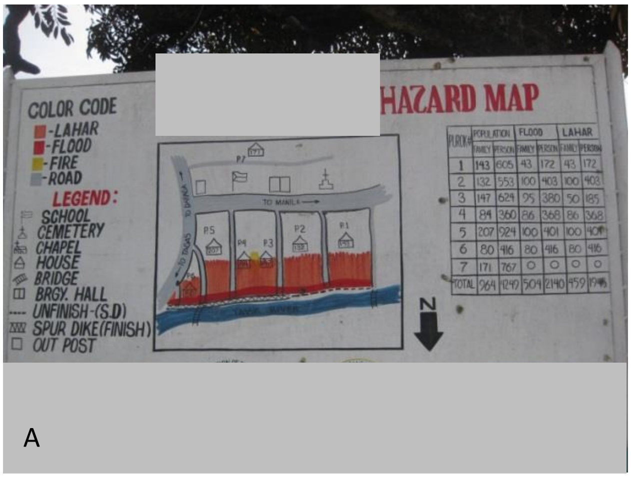
[14] Regional Programme Manager (Development INGO Ph); this was also mentioned during meetings with a local NGO in Manila and NAMRIA (informal meetings, September 2010).
[15] WASH-DRR Coordinator (INGO Ph1); Senior Programme Officer 1 (INGO Ph2); Executive Director (Local NGO Ph1)
[16] Executive Director (Local NGO Ph1)
[17] WASH DRR Coordinator (INGO Ph1); Point Person – DRR (Local NGO Ph2)
[18] WASH DRR Coordinator (INGO Ph1); Senior Programme Officer 1 (INGO Ph2)
[19] Senior Programme Officer 1 (INGO Ph2)

If it is within the project timeframe (which may be as short as six months) and covered by the budget then the NGO can facilitate and review the hazard assessment:

> *'we validated the* [PHVCA] *result like 3 times already and when the group...conducted the* [PHVCA] *workshop here...they mentioned hazards but when we conducted this year the P3DM and the community level development planning we've validated* [PHVCA] *result twice and some of the hazards are omitted – some have added a new hazard, some were omitted.'* (Project Officer – DRR, Local NGO Ph3)

However, their review reflects a short-timeframe (within six months) and might only account, for example, for seasonal change in hazards rather than a real change to the hazard profile. Whilst Point Person for DRR (Local NGO Ph2) claimed that a community would update their flood hazard map '*every three months*', Executive Director (Local NGO Ph1) admitted that an absence of facilitation makes it difficult to ensure the hazards and risks are being updated. In the example of Local NGO Ph2, the researcher was fortunate to visit one barangay over both the September 2010 and October 2012 field visits and was able to compare the community hazard map (Figure 5.1). The lack of maintenance of the map calls into question whether the PHVCA process truly encourages review and reassessment over time. Part of the problem came down to the finite funding for this project and the termination of their partnership with the supporting INGO.



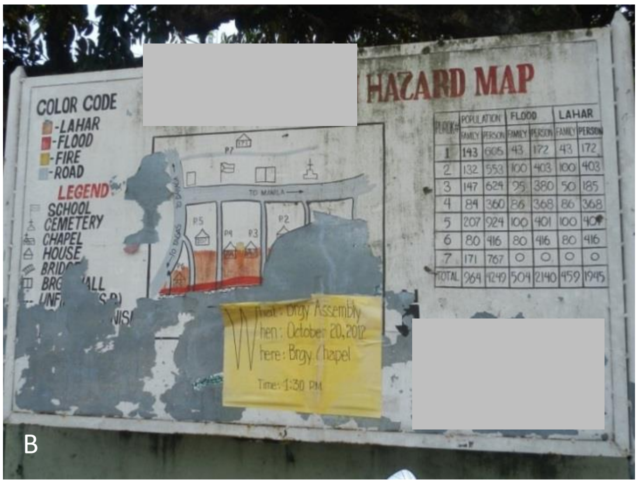




Figure 5.1: Example of a community hazard map. Image to the left (A) was taken in September 2010 and the image to the right (B) is of the map in October 2012. The names of the barangay, NGO and donors have been removed to ensure anonymity. Source: author's own.

Furthermore, in the context of review, the omission or inclusion of hazards can be heavily influenced by community perceptions and capacities and thus, action rather than analysis is the focus of prioritisation:

> *'for example drought…because they identified flood last year as one of the major causes of the low productivity yield so when we did the 3D mapping… it started raining so they don't consider it* [drought] *as a hazard anymore, they omitted it …Basically some of the hazards are omitted because the community does not know how to come up with a solution how to address so they tend to go for the hazard that they could address tangibly, like construct spillways or barriers or walls.'* (Project Officer – DRR, Local NGO Ph3)

Whereas the Philippine interviewees are more aware of the need to review hazard profiles than the Head Office interviewees (Study A), it is not clear how this is sustained after the project is over; especially given that many interviewees commented on the low capacity of the local government in the context of DRR[20].

Similar to the findings from Study A, the process of assessment is limited to the community-scale. In spite of this, there was a general sense that appreciating the wider natural system scale and the dynamic nature of hazards and risks was more apparent in the Philippines, but more systematic means of assessing these are required in order to account for multi-hazards and changing hazard threats.

**(3) Are NGOs, generally, not utilising science for the purpose of multi-hazard assessment?**

All interviewees emphasised the importance of community knowledge for the purpose of multi-hazard assessment:

> *'Yes* [community knowledge is the best source of information on hazards]: *they can even go back to 1950s – imagine! They are very positive in narrating what happened to them: their families, the communities.'* (Regional Programme Manager, Development INGO Ph)

But, in contrast to the UK interviews, the reliance on community knowledge is not only a reflection of its value but an acknowledgement of the lack of access to and availability of alternative information and technical knowledge:

> *'Based on our experience I don't know if call it best but primary* [source of information] *are the communities really, it's actually – the science people – there's no massive study of different hazards in different communities. So for lack of that, we would really rely more on local communities.'* (Executive Director, Local NGO Ph1)

[20] Executive Director (Local NGO Ph3)

Unlike the Head Office interviewees in Study A, all the Philippines interviewees emphasise the importance of augmenting and triangulating that community knowledge with available science:

> *'sometimes you do VCA and risk and resource mapping but then these priority hazards are actually on the top based on the experience of the community, based on what they see but not necessarily linked to the multi-hazard map so we ensure that, for examples, communities are also aware, that look these are the priority hazards based on the scientific community.'* (Head – DMS, Humanitarian INGO Ph)

The majority of the interviewees brought up the incorporation of science into their PHVCA without prompt from the interviewer, and the three who did not were all from Local NGO Ph3, which was largely new to DRR. The examples of utilising science varied from using secondary information to asking a consultant to compare the results of the PHVCA with hazard maps and satellite images.

Whilst interviewees did emphasise science in the context of climate change – with one stating that in a changing climate indigenous knowledge *'cannot stand alone'*[21] – there was also a sense that by combing local knowledge and science communities would have a better indication of the true cause of changes in hazards:

> *'But then they* [the community] *said now we have even shorter drought now we don't have water anymore because our watershed – they* [communities] *said "oh really, it is really good information", they said "this drought thing is not only now that there is climate change it has been there so why is that happening? And when we would listen to science they would explain its natural cycle, natural law of nature."'* (Executive Director, Local NGO Ph3)

Science was discussed and utilised much more in DRR hazard assessments compared with the findings of Study A:

> *'they* [the community] *could easily link the hazard to the environmental condition that they have…for example landslide they would just say: "yeah because it's already deforested" but what* [the hydrologist] *explained to us* [is] *it's not only logging, it's not*

[21] Point Person – DRR (Local NGO Ph1)

> *only deforestation that cause the vulnerability of the hazard like landslide: the soil structure, the slope of the area...that's only the time that I've learnt because we're thinking* [on] *all slopes they should plant trees. But he said know you have to think about the relationship of hazard to your action – we need science, explanation based on science could help the community better in doing the plan.'* (Executive Director, Ph3)

There was a greater emphasis on the role of existing scientific knowledge for the purposes of assessing the range of hazards beyond those directly related to climate:

> *'…in Albay, we have the Mayon volcano so…many people know about Mayon but most of them do not know science behind Mayon volcano: the gravity of how will it affect the community – the possibility of a major explosion – what will happen. …Most of us experience the typhoons but the science behind the typhoon should be familiarised by the people, especially the most vulnerable groups because here supertyphoons is very frequent.'* (Point Person – DRR, Local NGO Ph2)

This quotation emphasises utilisation of science by communities. However, before it can be used, scientific information was perceived to require translation[22]:

> *'it was us the NGOs who translated it to more understandable version*…[scientists'] *information been there for years in their brains and personal capacities had information for years but it hadn't been shared.'* (Executive Director, Local NGO Ph1)

With the assistance of a knowledge broker, in this case the NGO, the above example illustrates that information scientists took for granted was of utility to NGOs and the community, but required the NGO to translate it. Compared with the Head Office interviews (Study A), there was much greater acceptance of the direct engagement between a scientist and a community, which is explored below.

***Integration of science and community knowledge***

Those agencies utilising scientific information and partnering with scientists to the greatest extent tended to comment more on the limits of relying on community knowledge. Limits mentioned across the interviews included: the fact that *'indigenous knowledge'* is not always

[22] WASH-DRR Coordinator (INGO Ph1); Executive Director (Local NGO Ph3)

passed down[23], the short-term memory of this knowledge and the difficulty of convincing communities of a hazard that has yet to be experienced by them[24]. Three interviewees[25] remarked that science can help communities to identify threats previously unknown to them or bring credibility to DRR work:

> *'while you acknowledge that they* [communities] *should own and do something about it, but realising also that they're not the experts, that they need some guidance and this is where for example if there are some mitigation activities that we felt that it's not really worth it but you don't want to offend the community so you get some experts to tell them how to do it'.* (Head – DMS, Humanitarian INGO Ph)

A natural point of integration between science and community knowledge was apparent. The community was seen as the primary source of observations and information inaccessible to scientists, and the scientists have a role in explaining and attributing phenomenon communities describe (e.g. hazards) to their cause:

> *'scientist not always well informed or not having much information – so get from community (flows of river). But on the other side the community also not so familiar with other hazards, information, possibilities so the science explains…'* (Executive Director, Local NGO Ph1)

Five interviewees[26] said they would compare the community's assessment and hazard prioritisation with the scientific perspective. This surfaced through not only the facilitation role provided by the NGO in the simplification and communication[27] of scientific information to the community but also through direct engagement between NGOs, scientific institutions[28]

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[23] WASH-DRR Coordinator (INGO Ph1)
[24] Regional Programme Manager (Development INGO)
[25] WASH DRR Coordinator (INGO Ph1); Senior Programme Officer (INGO Ph2); Head- DMS (Humanitarian INGO Ph)
[26] Head – DMS (Humanitarian INGO Ph); WASH-DRR Coordinator, INGO Ph1; Senior Programme Officer 1 INGO Ph2; Executive Director (Local NGO Ph1); Point Person – DRR (Local NGO Ph2)
[27] E.g. Head – DMS (Humanitarian INGO Ph)
[28] Two representatives of the Philippine Institute of Volcanology and Seismology (PHIVOLCS) said that they work with various NGOs (hazard mapping and community based early warning systems). A representative from PAGASA shared an example of providing technical assistance (i.e. rain gauge installation and training) to an NGO (informal meetings, Manila, September 2010)

and communities. Four interviewees[29] emphasised that the process should begin with community knowledge rather than science and this was also suggested by a hydrologist working with Local NGO Ph3 and implied across the NGO interviewees by their description of the process of assessment:

> *'Information for hazard assessment – do it localised: tools introduced, people analyse their hazards based on their knowledge – we analyse scientifically with experts and scientists. But most important is that community do first, essence of hazard analysis from their knowledge….'* (Point Person – DRR, Local NGO Ph2)

It is unclear whether scientific information is assimilated prior to the assessment or if instead whether scientific opinion is only sought in the context of what the community identifies as a key risk. The sequencing of community and scientific knowledge has implications for the objectivity of the analysis and raises questions as to whether expertise are only brought in to address preconceived risks rather than assist in the identification of risks (similar to Study A). In a follow up meeting with the interviewee quoted above, this person explained that the process of integrating science should be iterative. This interviewee described starting with what the community know, then incorporating some scientific explanation of hazards, then 'digging deeper' to find out more from the community and then adding more science. This runs counter to the conventional project cycle management (PCM) model, where each action takes place in an orderly sequence (Twigg, 2004). Although this is only the experience of one individual, it echoes others who have attempted to integrate science (e.g. Landstrom et al., 2011). This discussion therefore highlights a potential barrier for integrating science.

***Challenges of integrating science***

There was little evidence provided of direct disagreements between community knowledge and science. The Head of DMS (Humanitarian INGO Ph) stated that the community had a '*very good batting average*' and tended to be in agreement with the scientist; however, the

[29] INGO Ph2; DRR Point Person, Local NGO Ph1; Head of DMS at Humanitarian INGO Ph

Executive Director of Local NGO Ph1 and the WASH-DRR Coordinator at INGO Ph1 were able to reflect upon instances when science challenged what the community were saying. Rather than causing confrontation, the main challenge of integrating science in hazard assessments appeared to be in terms of accessing science and engaging with scientists. This challenge was related to the limited capacity of government scientists, the cost of accessing scientific information, the challenge of communicating science and poor information and knowledge sharing[30]:

> *'…the government has not so much invested so much in science in sharing with community and (like us) with social scientists so this information were stopped there.'* (Executive Director, Local NGO Ph1)

Three organisations[31] mentioned the high cost of scientific input, one noting that this is particularly the case for multi-hazard assessments. The same interviewee suggested alternative free sources of information through support from the local government, information sharing with not-for-profit scientific organisations and an academic volunteering programme. Three instances of engagement were in the form of partnerships between NGOs and non-government scientific institutions[32]. Generally, however, engagements were informal[33] and either *ad hoc* or related to non-DRR elements of the NGOs' work, for example livelihoods[34]. It emerged that the source of information might be controversial as evidenced by the tension between the Manila Observatory (non-profit scientific research institute) and the Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). PAGASA (according to the government) should be the sole provider of weather related

[30] Executive Director (Local NGO Ph3); Hydrologist (academic) working with Local NGO Ph3 (informal interview)
[31] Senior Programme Officer 2 (HD INGO Ph2), Executive Director (Local NGO Ph3); Point Person – DRR (Local NGO Ph3); Project Officer – DRR (Local NGO Ph3)
[32] INGO Ph2 (and Local NGOs Ph1 and Ph2 through their partnership with INGO Ph2); Humanitarian INGO Ph; Development INGO
[33] A representative of the Mines and Geosciences Bureau noted some instances of when they had worked with NGOs but stated that they had 'no fixed linkage' (informal meeting, Manila, September 2010).
[34] INGO Ph2; Local NGOs Ph1 and Ph3

information and, as a consequence, collaborating with the Manila Observatory could result in tension with PAGASA[35]:

> *'Yes* [we worked with both] *but some dynamics with that – during project managed to struggle with the dynamics.'* (Executive Director, Local NGO Ph1)

The government agencies might, however, not always work in favour of the NGOs and local communities. The Executive Director of Local NGO Ph3 shared an example of their difficulty of trying to get a hazard map the Mines and Geosciences Bureau (MGB) had conducted for a cement company whose factory was encroaching on a community this interviewee was trying to assist. As such, it was apparent that scientists are not necessarily going to approach NGOs; instead NGOs need to make the conscious decision that science is needed and then be resourceful in their means of accessing it. INGO Ph2 employed a former academic, who identified a scientific information gap in NGO DRR and CCA work; consequently, they established links with the local university and a not for profit research centre. This example indicates the importance of employing academics within NGOs.

As a consequence of their partnership with INGO Ph2, Local NGOs Ph1 and Ph2 have had the benefit of three years of scientific engagement:

> *'For three years of scientific engagement, it help a lot only not only for NGO level, for NGO workers; a lot of realisations, a lot learning and a lot of unlearning in working with them. More so we were able to share it well with communities we work with so we were really able to serve as channels for the community we work with because of course they* [scientists] *cannot go here frequently.'* (Executive Director, Local NGO Ph1)

The quotation above implies that the benefit of scientific engagement may only emerge over time, which emphasises why it might be challenging to endorse this type of engagement to NGOs because they tend to want immediate results (Roper, 2002). The Senior Programme Officer 1 from INGO Ph2 (the agency with the greatest experience of scientific engagement)

[35] During an informal meeting with an international NGO representative, the difficulty of trying to work with another agency who were 'more scientific' and tended to work with the Manila Observatory was described. The interviewee tended to work with PAGASA instead (Manila, September 2010).

noted the challenge of collaborating with scientists who encourage pilot work and operate at different timescales. The Head of DMS at Humanitarian INGO Ph also commented on the differing approaches between scientists and NGOs and communities, the example below suggesting that scientists observe a problem more clinically, with less appreciation of the implications of their decisions:

> *'the scientific community tells me: "no, no, no we're not going to do that* [tsunami warnings system] *because when you have tsunami you should have hill"; then I just told them: "look, are you telling me now that you're condemning these 20,000 or more than 20,000 people to death just because they don't have a hill? Or isn't the essence of early warning is to do an early action?"* (Head of DMS, Humanitarian INGO Ph)

Whilst interviewees claimed that scientists would require information from the community[36], it appeared as though engagement was typically one way – with scientists providing information rather than receiving it (confirmed by the informal meetings conducted during the study[37]) – and implied by the fact that the onus was on the NGOs to bring the scientists to the community. Several interviewees noted that scientists do not tend to come to the community level – either owing to reluctance to share knowledge[38] or owing to the institutional constraints upon scientists themselves (e.g. the lack of locally positioned personnel)[39]. Consequently, the majority of science comes from what the NGOs can themselves access, which is inhibited by cost and the lack of available information. The scale of available scientific analysis may not be readily transferrable to the small spatial scales adopted by NGOs and one interviewee[40] commented on the fact that government maps tend to be outdated.

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[36] E.g. Executive Director (Local NGO Ph1)

[37] During an informal meeting with an INGO, an example was shared of when a community disputed climate change tends, but PAGASA would not stand down (informal meeting with INGO representative, Manila, September 2010)

[38] Executive Director (Local NGO Ph1); Executive Director (Local NGO Ph3); Hydrologist (informal meeting)

[39] WASH-DRR Coordinator (INGO Ph1); Executive Director (Local NGO Ph1)

[40] WASH-DRR Coordinator (INGO Ph1)

It was emphasised that science had to be creative and simplified since communities might not necessarily be interested in science[41]:

> *'For us we always say simplify things rather than being very scientific with the community…they are more knowledgeable basically than us, it's just putting their knowledge and their background on this perspective we want them to achieve. Sometimes if you impose something on them they will not also understand it; it's more on letting them process'* (Head of DMS, Humanitarian INGO Ph)

The above quotation emphasises the key role of facilitation in the process. One of the main challenges facilitators have is in the communication of science and how to translate even DRR concepts into layman's terms[42]:

> *'Really find it hard to have direct translation of what is meant by hazard, what is meant by risk in exact term, what is meant by vulnerabilities'* (Regional Programme Manager, Development NGO Ph)

The DRR Point Person (Local NGO Ph2) discussed their recent attendance at an urban DRR training event and noted that the consensus amongst the event participants was that the scientific discussion of hazard and risk must come from technical people[43]. However, they noted that Senior Programme Officer 1 of their partner NGO (INGO Ph2) countered that the scientific information can also be discussed by non-scientists:

> *'we* [NGOs] *can integrate science into community development work – scientists don't always have this skill'* (Senior Programme Officer 1, INGO Ph2)

Conversely, three[44] interviewees described the limitations in their agency's own technical capacity:

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[41] Point Person – DRR (Local NGO Ph2; informal meeting)
[42] Point Person – DRR (Local NGO Ph2)
[43] PHIVOLCS have recognised the need to translate science since the late 1980s and thus they have separate projects for (1) 'hard core' science and (2) the dissemination of information (informal meeting, Manila, September 2010); NAMRIA mentioned that they attempt to translate terms into the layman as far as is possible (informal meetings with PHIVOLCS and NAMRIA staff, Manila, September 2010)
[44] Executive Director (Local NGO Ph1); Point Person – DRR (Local NGO Ph2); Project Officer – DRR (Local NGO Ph3)

> *'…NGOs in Philippines are social workers; so not really scientific, science people. It's really hard to work in communities with so much science involved but you are not a scientist.'* (Executive Director, Local NGO Ph1)

It was in recognition of this limited capacity within this agency and their partnership with INGO Ph2 that they made the decision to engage with scientists for the purposes of DRR.

Whilst the role of science in hazard assessments appears more appreciated in the Philippines compared with the interviews with Head Office in the UK, it is clear that this represents the ideal rather than the norm:

> *'so I think if there's a way to have the local knowledge and the scientific knowledge come together in order to explain causes, effect, impact - the inter-relatedness of hazards experienced by the community I think that would be better; but as for now not really fully utilising the scientific data on hazards'* (Project Officer – DRR, Local NGO Ph3)

***The utilisation and integration of science for (multi-)hazard assessments: current state of play in the Philippines***

Community knowledge forms the core component of hazard assessments conducted by the agencies interviewed, as (1) interviewees perceived that the community are most knowledgeable of the problems *in situ*; (2) they adopt the same methods that pertain to participatory principles of PHVCA, which emphasise community ownership and empowerment and (3) in contrast to the UK interviews, interviewees noted or indicated that the reliance on community knowledge is also due to a lack of alternatives.

Amongst all the interviewees, scientific knowledge and understanding are valued highly. NGOs appear to have a three-fold role as instigators of engagement with scientists, providers of secondary information and brokers of scientific information that scientists might provide, however they have the same capacity problems (e.g. being comprised of mostly social scientists) as observed in Study A. The ideal is to have direct engagement with scientists and communities, however barriers including the high cost and the fact that it is unlikely that scientists will visit communities suggests initiating the engagement may be challenging.

Interviewees emphasised that the essence and starting point of the hazard assessment should be the information and knowledge provided by the community, with a subsequent validation (explanation) by scientific experts or comparing the results of the community assessment with secondary scientific information, primarily hazard maps. However this sequencing of sources of information may generate bias in the process. What was proposed as a useful means of avoiding this bias was through one interviewees' emphasis on the iterative process of integrating science and community knowledge.

## 5.3 Discussion of comparisons across studies A and B

The interviews with 33 participants (26 in Study A and nine in Study B) were conducted in order to address three concerns:

(1) whether and how NGOs are conducting multi-hazard assessments;

(2) whether they use science for this purpose;

(3) what factors constrain or enable their ability to implement these assessments.

Whilst the sample from the Philippines was comparatively smaller, these two studies provided the opportunity to form some insight into NGO approaches to multi-hazard assessment and whether there is a difference between the perceptions of those at Head Office compared with those of in-country NGO staff. Chapters 4 and 5 conveyed the similarities in NGO approaches to (multi-)hazard assessment across the studies, but the findings also illustrated distinct differences between Head Office and in-country (Philippines) NGOs' views and approaches, particularly in terms of the actuality of implementation and perceptions of hazard, science and scale. Table 5.2 provides a summary of the main points of comparison across the two groups.

In answer to the first point outlined above, risk from multi-hazards is considered only so far as the comparative ranking of different hazards and their cross-cutting vulnerabilities, and PHVCAs do not readily account for the interrelations between hazards in an analytical and anticipatory manner. Whilst multi-hazards and their interrelations are more appreciated in the Philippines, there still lacks an approach to multi-hazard assessments that ensures not only that all hazards are included, but also that their manifestations are anticipated. Furthermore, the approach of identifying common vulnerabilities may be suited to 'quick wins', but it might not be so applicable in the context of interacting hazards, where vulnerabilities might change owing to, for example, the simultaneous occurrence of two hazards. The emphasis on qualitative, community knowledge and preconceived ideas regarding what hazards or threats need to be addressed (e.g. climate change) questions how well hazards in general are assessed.

In answer to the second point, science appears generally not integrated for the purpose of these assessments, however there was greater emphasis on utilising science for the purpose of PHVCA amongst the Philippines interviewees compared with the Head Office interviewees. Related to the third point, the lack of utilisation of science more generally and, as such, the reliance on community knowledge was one of three constraints on the adoption of a true multi-hazard approach (one that account for all hazards in a place and their interrelations)

NGOs are struggling to adopt a true multi-hazard approach owing to constraints on the process of assessment (e.g. whether a tool adopts a CCA or DRR lens and the skill of the facilitator), the utilisation of mostly community knowledge and the fact that the analyses are spatially constrained and largely static. Head Office NGOs are seemingly advocating for more holistic and integrated approaches to risk reduction, however the branding and design of toolkits for analysis is compartmentalised, so does not allow this. In-country interviewees tended to place more emphasis upon the process of PHVCA and less on the importance of specific tools;

however feedback from Local NGO Ph3 indicated how the emphasis on tools can be at the expense of the quality of analysis.

Table 5.2 Summary of the key points of comparison pertaining to the topics discussed across studies A and B.

| Point of Comparison | Study A (Head Office, two research institutes and three in-country staff) | Study B (NGO staff in the Philippines) |
|---|---|---|
| ***Multi-hazard approach*** | The principle of assessment allows for multi-hazards to be identified; however the assumptions behind analytical lenses (e.g. DRR and CCA), the process of analysis and reliance upon community knowledge constrain the assessment. | Practitioners are keenly aware of the need for a multi-hazard approach; however they are bound by similar constraints in terms of reliance on facilitation and community knowledge (as science is not always available). |
| ***Interrelations between hazards*** | Whilst a number of interviewees remarked upon these, it was notable that they were more appreciated by the Philippine participants. The method of assessing each hazard discretely in order to identify overlapping vulnerabilities may not allow for secondary or cascading hazard instances to occur. These links might only be made through strong facilitation. | There is perhaps a greater awareness of these and the links between the natural environment and hazards (and not just climate change); however, again, these links will only be made through strong facilitation. |
| ***Emphasis upon climate change as a threat*** | All interviewees (whether from a DRR or CCA background) discussed climate change and their concern regarding what this might mean for development and DRR. | Climate change does not appear to have relative importance above other hazards, although this is likely to be due to the fact that most agencies are new to CCA and that they are addressing it in the context of existing climate variability owing to the frequency of weather related disasters. |
| ***Appreciation for and use of community knowledge*** | Community knowledge is the essence of the PHVCA process, owing to the emphasis upon empowerment, ownership and a process free from external influence. | Community knowledge is the essence of the PHVCA process, owing to the communities understanding of what affects them. Reliance on community knowledge was also acknowledged by interviewees as partly owing to a lack of available and suitable scientific information and available scientists. |

| | | |
|---|---|---|
| ***Appreciation for and use of science*** | All participants valued science but mostly owing to its role in determining climate change. In spite of this, it is not widely integrated into hazard assessments. | Science is incorporated into hazard assessments more readily and is not only understood as being useful for anticipating climate change but also for understanding the cause and risk of a number of different hazards. However, it is apparent that the application of science constitutes the recognised ideal and not necessarily the norm. |
| ***Hazards tend only to be assessed at the community scale*** | National scale assessments are more for the benefit of understanding the institutional landscape, rather than a detailed analysis of hazard risk. | The emphasis was on the need for detailed information at the local level, which NGOs and communities can provide. |
| ***Concern with anticipating future risk appears primarily in the context of climate change*** | The need for more holistic approaches to risk reduction, implementing adaptation strategies and revising approaches to PHVCA seem to be down to a great deal of concern regarding an uncertain 'changed climate' future. In comparison, other hazards appear to not be viewed with the same level of uncertainty – these are perceived to be 'known'. Moreover, the historical emphasis within DRR and the largely static nature of PHVCAs means that approaches are not particularly anticipatory. | Climate change was similarly viewed in the context of future risk; however the emphasis was less apparent. The awareness of the dynamic nature of risk was more obvious, along with the need to review assessments however similar practicalities of ensuring hazard assessments are reviewed were noted. |

There were a series of themes that emerged during the interview analysis, but the two that emerged as key constraints and opportunities for assessing multi-hazards were scale (temporal and spatial) and knowledge. The scale at which multi-hazard assessments are applied and the knowledge utilised in order to implement them largely determines the extent to which the components of multi-hazard are addressed in the course of the assessment. How these are incorporated relates strongly to the methodological approach of PHVCA, which is underpinned by the skill of the facilitator whose responsibilities ranged from ensuring the process is community led to identifying when communities need additional information (Cronin et al., 2004). How NGO practitioners perceive and value scale and knowledge has major implications for the successful identification and assessment of multi-hazards. The following discussion synthesises the results of the two studies under three major themes: method, knowledge and scale.

### 5.3.1 Methods and process: practical and institutional constraints

During the interviews, a number of institutional (e.g. donor-driven funding for CCA) and organisational (e.g. lack of internal scientific capacity) constraints emerged, however directly related to the process of hazard assessment were a series of assumptions and decisions made by agencies and individuals that influence the degree to which the assessment of multi-hazards is incorporated in the design of PHVCAs (see Figure 5.2). Designing tools to address risks through a DRR or CCA lens negates the claim that they naturally capture all hazards.

The process of assessment is highly qualitative and adopts a fairly short-term perspective, owing to the reliance upon community knowledge. Moreover, hazard prioritisation is based upon what is perceived to be the greatest threat relative to the community and NGO's capacities to address it. As such, there is a balance between ensuring actionable results and safeguarding sufficiently rigorous analysis; however, it was apparent that the balance would often shift in favour of action at the expense of thorough analysis of multi-hazards. Participatory research is designed to be unstructured and emergent, yet this creates difficulties for the NGO in the sense that they are managing a tension between the influences of the donor, their own organisation's remits and capacity to address the range of threats the community identify, as well as ensuring that the process is led by the community.

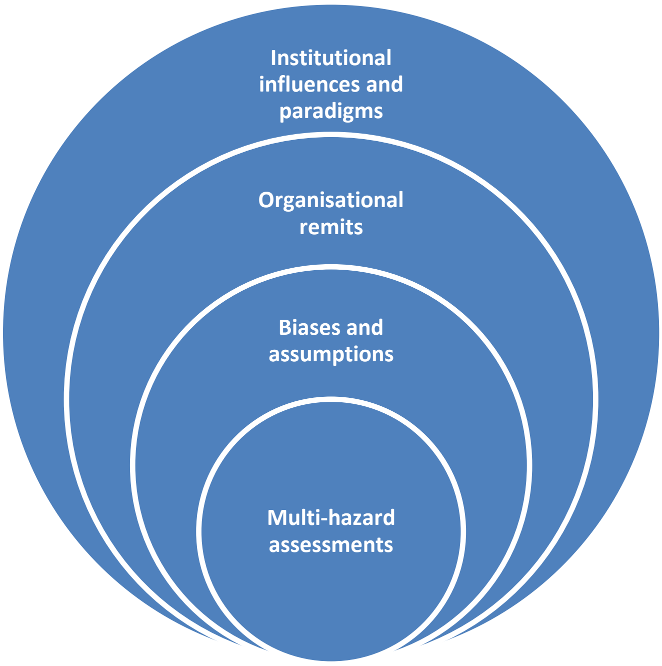


Figure 5.2 A stacked Venn diagram demonstrating the influences on the process of multi-hazard assessment, which range from the donor driven need to address DRR or CCA, the remit of organisations and the biases and assumptions of toolkit developers, implementers and communities that all influence the extent to which multi-hazards will be sufficiently assessed. These factors influence the extent to which science and appropriate analytical scales are adopted.

The PHVCA approach might be suitable for participatory action research, which focuses upon ownership by the community and transformative results, but there is perhaps a need to question whether primarily social science research methods allow for a sufficiently thorough assessment of multi-hazards and scenarios for occurrence. The emphasis upon qualitative approaches is embedded within the social science research methods adopted, but, it is misleading to liken participatory approaches solely with qualitative data (see Chambers, 1997: 135). Furthermore, the Kenyan representative from INGO C noted that partners were asking for more quantitative methods to conduct PHVCA. Whilst there is concern that the process of assessment does not become too focused on data collection[45], coping strategies are affected by the physical characteristic of hazards, thus detailed hazard (e.g. flood depth) and vulnerability (e.g. height of home foundations) data are required (McCall and Peters-Guarin,

[45] DRR Consultant

2012). Five[46] of the interviewees in the Philippines noted the need for detailed analysis and the avoidance of collecting very general information.

One interviewee[47] noted that it is not possible to develop a tool that addresses everything; so, given the reliance on good facilitation, perhaps emphasis needs to be upon identifying what skills and training staff require to conduct multi-hazard assessments. This was partly recognised by the Conservation INGO in their decision to develop a training package rather than a toolkit and the fact that some in-country interviewees emphasised the process of PHVCA rather than tools. Head Office interviewees noted that training on tools is important; however these interviewees noted that budgets and allocation of time for this has been overlooked in the past. Periods of training were described as ranging from a couple of days to ten days, with agencies describing varying experiences, including an instance when partners refused training[48].

Lastly, interviewees were reflexive and very mindful of the different sources of influence and bias upon the PHVCA. These influences were either noted by the interviewees or observed by the interviewer can be divided into four sources: the organisation, partners, individual staff (e.g. toolkit developers, project managers, etc.) and communities. At the same time, in all but a few cases interviewees were less aware of how they might adversely affect the process because of what they were failing to provide. NGOs were noted to be generally comprised of social, rather than physical or natural, scientists and therefore might not be in a position to provide the community with the additional information they require in order for them to identify and prioritise hazard risk. The acknowledgement of this was reflected by the fact that Philippine NGO staff emphasised the need to engage with the scientific community.

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[46] WASH-DRR Coordinator (INGO Ph1); Executive Director (Local NGO Ph1); Executive Director (Local NGO Ph3); Adviser – DRR (INGO E)
[47] Programme policy Management Team Member – DRR (INGO F)
[48] Adviser – DRR (INGO B)

### 5.3.2 Sources and perceptions of knowledge

Participatory action research is supposed to place local knowledge on equal footing with external scientific knowledge (McCall and Peters-Guarin, 2012), however there is an almost total reliance on community-based knowledge for the purposes of hazard assessment. The knowledge underpinning hazard assessments comprises the past and present hazards as experienced by those at risk, owing to: (1) the perception that the community are the most knowledgeable about their situation and (2) the philosophy of participatory action research, which emphasises community empowerment.

It was surprising to discover that interviewees also value natural science, but it became apparent during the course of the interviews that engagement with scientists and the utilisation of science is fairly limited and largely not incorporated in the assessment of hazards by those at Head Office. Engagement with science is more accepted amongst in-country interviewees, particularly those interviewed in the Philippines, but is lacking owing to practical barriers to scientific engagement. Therefore, in the context of the Philippines a third factor can be added to the above list: a lack of alternative sources of information.

Despite the growing awareness of the value of science, scientific engagement is hindered by the assumptions of individuals and organisations. Of particular note is the apparent uncertainty implied throughout the interviews of how to use science and, in particular, the lack of understanding of what science is most useful for the purposes of hazard assessment. The perceptions of science shared by interviewees represent the assumptions and understanding of a group of largely non-scientists, a reflexive observation made by only a small number of interviewees. Interviewees seemed particularly concerned about future disasters and risk, but their concern does not seem to embed a multi-hazard perspective owing to the assumption that DRR looks historically and because Head Office interviewees are making the assumption that emergent threats and unknown future risk are purely driven by climate change.

Through the tendency to discuss science solely in the context of climate change, science was perceived by Head Office interviewees primarily as an opportunity to better anticipate future climate risk rather than for the purpose of better understanding the past and current hazard situation, which are primarily drawn from community experience. This was due to interviewees' concerns over how to plan for a particularly uncertain future and because community knowledge may be redundant for this purpose. However, couching science solely in terms of climate change is hindering the wider application of science for understanding and attributing causes of natural hazards and environmental change. There appeared a relatively poor acknowledgement of other 'science' that might be more applicable and easier to use than the very uncertain and poor resolution of climate science. Study A interviewees also appeared to make the assumption that future risk from geophysical hazards is more predictable, yet the reliance on community knowledge means that they are perhaps naïve in this assumption.

In the Philippines, value was placed on existing scientific information, such as hazard maps and expert opinions, which with good communication could be transformed into something useable. Thus, there is an opportunity to engage with science and scientists in more relevant ways. In the Philippines, they acknowledged that scientific information is not often at the scale required for community-based analysis but by sharing information provided by the communities, scientists could help determine why disasters occur. Although more appreciated by in-country staff (across studies A and B), the integration of science is limited owing to problems related to access to and availability of useful science along with the politics involved regarding sharing information and the source of science. Likewise, the science does not appear to be coming to NGOs; it is largely up to the initiative of individuals, through their informal contacts, to access the information required.

It was emphasised in all but one case[49] that the PHVCA process should begin with community knowledge before being compared with the science. However, this sequencing of knowledge needs to ensure an unbiased inclusion of science (i.e. that it does not serve to simply justify the hazards that have been prioritised) and, as identified by one interviewee, adopt an iterative approach. Whilst the application of scientific expertise in the context of identifying technical solutions is vital, it is imperative that the analysis of hazard is as rigorous and objective as possible and not preconditioned by *a priori* defined projects and programmes.

Given the perception amongst Head Office interviewees that scientists should not or, in the case of in-country interviewees, are unlikely to visit communities, practitioners manage the external information and knowledge being provided for and utilised during the PHVCA process. As such, if they have preconceived ideas about what hazards should be considered or what science is actually of value, biases will emerge. Whether they have the knowledge and skills to provide the necessary science was taken for granted by Head Office interviews, but one Philippine interviewee[50] particularly emphasised that science can be communicated by non-scientists.

The practical (real) and perceived barriers to the integration of science are summarised in Table 5.3. These are divided into the barriers perceived by the interviewees and those that the researcher identified as hindering the incorporation of science into NGO assessments of hazard.

[49] Senior Climate Change Researcher (Research Institute B)
[50] Senior Programme Officer 1 (INGO Ph2)

Table 5.3 Noted and perceived constraints and barriers upon the integration and utilisation of science; text in italics indicates Head Office (UK) respondents, bold text represents Philippine respondents and bold and italicised text indicates when representatives from both groups mentioned these.

| Identifying body | Ideological constraints | Barriers to scientific engagement | Barriers to utilisation of science |
|---|---|---|---|
| ***Participants*** | • *The positivist approach of science*<br>• *'North' set-agendas/ Ideologies* | • ***NGOs are not natural scientists***<br>• *Individual/institutional capacity*<br>• ***The different approaches of scientists and NGOs***<br>• ***Cost***<br>• **Limited capacity and resources of local scientists compared to Head Office scientists** | • ***Access and availability*** **(e.g. outdated maps;** ***expense*****; limited capacity of local government scientists)**<br>• ***Lack of scientific capacity within NGOs***<br>• ***Poor communication and understanding*** **(e.g. science requires simplification;** ***different objectives between scientists and NGOs*****)**<br>• *Scientific uncertainty*<br>• *Partners and communities might struggle to understand and utilise* |
| ***Researcher*** | • *There is a greater emphasis on vulnerability than hazard*<br>• ***Participants' perception that science is about forecasting and predicting climate change*** | • *The participants' assumptions about partners and communities' ability and desire to engage with scientists*<br>• *Ensuring community empowerment*<br>• *A lack of knowledge as to what science may be of use*<br>• **Contention regarding the source of science** | • ***The different scales and types of data and analysis compared with community level PHVCA***<br>• *Uncertainty regarding how to use science*<br>• *Not enough emphasis on the available science which could be of use* |

### 5.3.3 Temporal and spatial scale of analysis

Whilst the data resolution and uncertainty of climate science arguably hinders its applicability to NGO community-based risk reduction work, it does highlight the need for agencies to (1) use science and (2) consider larger geographical and prospective scales for the purposes of their risk reduction work so as to be better at anticipating the possible occurrence of disasters.

Furthermore, some of the examples of scientific engagement were in the context of the analysis of areas much larger than communities.

Hazard interrelations are spatially and temporally determined (Kappes et al., 2011). NGO assessments of hazard are, however, typically limited to the geographical scale of a small community and tend to reflect on past events without necessarily anticipating future change. Historical analysis is a strong component of the NGO claim to a multi-hazard approach to PHVCA because different hazards are identified through the creation of timelines (historical analysis) and seasonal calendars (short-term analysis). Temporally the process of hazard analysis is constrained by the extent and degree to which the community can reliably remember disasters, especially when specific data (e.g. frequency and impact) are required, and their perception of risk.

It is clear that most agencies are still grappling with the differences between CCA and DRR. NGOs are familiar with acting in the short-term, so they are finding it difficult to address adaptation because it inherently deals with an uncertain future and is reliant upon looking at timeframes 30 to 50 years or more from now. Perhaps there is an opportunity for NGO staff to reflect on what it is they want communities to adapt to and why it is that they do not consider geophysical natural hazards over these same timeframes. An absence of an anticipatory approach to all hazards is worrying, since communities may not have experienced multi-hazard disasters in the past but might be at risk from future events.

A key component of anticipating risk is reviewing multi-hazard profiles and updating hazard maps and contingency plans over time, which does not appear to be embedded in the PHVCA process. Hazard prioritisation is based upon an analysis of the past and, since the focus is on the experiences of the community, it may only reflect the more recent past and the current situation. There is a methodological barrier to the successful review of hazard assessments that rely almost entirely upon community knowledge and qualitative measures; whilst qualitative baselines can be compared over time, this only succeeds if the same community members are consulted since the process, if not compared with scientific measures, is based on their perceptions. Twigg (2004) acknowledges this but argues that the advantages of participatory community assessments outweigh the limitations, as they provide a more detailed analysis and understanding of the communities' situation whilst also identifying their capacity to deal with the situation. Whilst this is a measure of success for any participatory approach, it is questionable whether identification of risk from multiple hazards and their interrelations by communities and NGOs can be achieved without means of prioritising and quantifying hazard profiles over time.

NGO interviewees were generally concerned with the lack of local information, therefore it is perhaps necessary to focus multi-hazard analysis at this scale but at the same time take into account the wider natural (as well as socio-political) systems as the source of hazards (Lee and Jones, 2004) or environmental change might be beyond the boundaries of the community and the scope of community based risk assessments. However, there is a lack of systematic appraisal of the threat from multi-hazards by international NGOs from the national to local scale. This situation is accompanied by a gap in assessing the environmental processes and wider natural systems that may affect the incidence of natural hazards, explain changing local climates and help to anticipate interrelated and multiple hazard events. There is renewed interest in the analysis of community risk within the context of natural systems; however practical implementation is not yet widely apparent. An opportunity to address longer timeframes and greater spatial scales could be through collaboration with conservation organisations (who already work at these scales) and scientists, who can provide a wider overview:

> *'Dr* [A] *provided information on framework for river basin approach – we use that already, it's a part of our advocacy framework so that's how we tap different agencies.'* (Executive Director, Local NGO Ph3)

The discussion has highlighted a number of barriers to the adoption of larger and longer scales of analysis. In a similar manner to Table 5.3, Table 5.4 summarises the barriers to the integration of different scales from the perspective of the interviewees and the researcher.

**Table 5.4**: Summary of the constraints and barriers to the adoption of more expansive geographical and temporal scales by NGOs.

| Identifying body | Ideological constraints | Barriers to the adoption of larger geographical scales | Barriers to the adoption of temporal, prospective, scales |
|---|---|---|---|
| ***Participants*** | n/a | • NGOs do not want to lose the essence of community-based assessments.<br>• Limited capacity of the organisation. | • Communities are concerned with short-time frames.<br>• Limited ability to review hazard assessments.<br>• DRR has short-term perspective. |
| ***Researcher*** | • Essence of participatory processes and community empowerment.<br>• The contradiction of CCA (conceptually long-term; practically short-term – potentially causing confusion). | • Uncertainty as to how to do this (need is being recognised but little action). | • Respondents' perception that science is about and predicting climate change.<br>• Action based approaches addressing immediate needs. |

## 5.4 Implications for the second part of the research

Chapter 3 outlined that the research was divided into two complementary parts. The first part has identified that NGOs are generally not adopting a multi-hazard approach in their assessment of risk, so the next part of the research looks to explore an actual case of multi-hazards and their assessment in order to compare the findings with those of part one. There is a need to take the rather conceptual term of ‘multi-hazard’ and understand the reality of the interrelations between hazards.

Owing to participants’ perceptions, much of the above discussion viewed science wholly within the context of climate change. Therefore, the following case study analysis not only looks to ground the multi-hazard conceptual framework identified in the literature review but also to identify how science assists in the assessment of multi-hazards. The case study was chosen during the same scoping study to the Philippines (Study B, September 2010). The case selected for the purpose of this multi-hazard analysis is introduced in the next chapter.

# Chapter 6: Introduction to the case study

Chapter 6 introduces the second part of the research, which comprises the analysis of a case study of an interrelated multi-hazard disaster: the 2006 Typhoon Reming triggered lahars at Mayon Volcano in the Philippines. The chapter begins with a rationale for the case selected, along with an overview of the location of the case study and the multi-hazard and lahar history of the area. Section 6.2 summarises the primary methods used to collect information about the case: semi-structured interviews, field observations and secondary data.

## 6.1 Rationale for selected case study

A conceptual framework for characterising multi-hazards was proposed in Chapter 2 from the review of the literature. In Chapters 4 and 5, multi-hazards and their assessments were discussed mostly in general, hypothetical terms by interviewees, with only a few sharing actual examples. The second part of the research therefore looks to ground the conceptual and abstract use of the term 'multi-hazard' in the context of a multi-hazard case study, in order to better understand the relationships and processes it suggests.

Assessments of interrelated hazards have received less attention in the literature compared to the analysis of comparative hazard risk, and many multi-hazard studies have been implemented in developed, rather than developing, countries (where disaster databases are more available) and have not considered NGOs and vulnerable communities as decision-makers (e.g. Greiving et al., 2006; Kappes et al., 2011; Marzocchi et al., 2012a). Consequently, the decision was made to explore interrelated hazards using a case study of one hazard triggering another in the Philippines.

Of the four multi-hazard interrelations conceptually framed in Chapter 2, it was deemed appropriate to focus upon ‘causation’ (one hazard triggering another) as it was thought too challenging to address all four of the categories within a single case. The choice of causation was because cascading hazards are commonly cited as a necessary consideration in multi-hazard analysis (Kappes et al., 2011), but few have attempted to quantify this interrelation (Marzocchi et al., 2012a). Mass movement hazards are a natural choice for the analysis of multi-hazard triggering owing to the fact that these are hazardous phenomenon that are often the consequence of other hazards and can also trigger subsequent (secondary) hazards (see Chapter 2). The selection of lahar was owing to the fact that they are a product of volcanic settings, often as a consequence of the interaction of more than one hazard (e.g. typhoon and eruption), and are, therefore, intrinsically multi-hazardous.

The case of the 2006 Typhoon Reming triggered lahars at Mayon Volcano emerged during interviews with NGOs, communities and local officials in Albay during the scoping study to the Philippines (September 2010; Chapter 5). This disaster had left a lasting impact on the province and represented a case of one hazard triggering another in one of the most multi-hazardous locations in the Philippines. Prior to the disaster, the Philippines Institute of Volcanology and Seismology (PHIVOLCS) had conducted and produced lahar and other hazard maps for the area, demonstrating that the technical knowledge for evaluating hazard at Mayon existed (Orense and Ikeda, 2007). The case study, therefore, presents the opportunity to explore the role of science in assessing hazard interrelations.

The focus of the study is the lahars that were triggered at Mayon. The findings regarding this component of the disaster are, however, analysed within the context of the multi-hazard characteristics of the disaster more widely in order to give a thorough reflection of the considerations that have to be made prior to and during a multi-hazard disaster. The following section introduces the context of the case study, in terms of the location and history of lahar hazard at Mayon.

## 6.2 Geographical and physical setting

The Typhoon Reming lahars occurred at Mt Mayon volcano, which is currently the most active volcano in the Philippines (Aspinall et al., 2011). Mayon is adjacent to the capital of the province of Albay – Legazpi City (Figures 6.1). Albay is located in the Bicol region and is readily cited as one of the most disaster prone provinces in the Philippines (Citizen's Disaster Response Center, 2012; Usamah and Haynes, 2012). Figure 6.2 outlines the population exposure to volcanic, typhoon (wind and storm surge), flooding, landslide, lahar and tsunami hazards. Figure 1.1 in Chapter 1 demonstrated that Albay is within the tropical storm intensity zone 4, which means there is a 10% (or greater) probability of a storm of intensity 210 to 249 km/hour striking in the next 10 years. The province is also exposed to earthquake hazard (see Figure 1.1); however exposure statistics were not available. According to the 2007 census, Albay has a population of 1.9 million, of which 175,843 live in Legazpi City (National Statistics Office, 2007). 42% of the population live below the poverty line (Usamah and Haynes, 2012).

As a consequence of the multi-hazard setting, and in conjunction with strong political will, leadership and support from international donors, Albay has become one of the leading provinces for DRR and CCA in the Philippines (Provincial Government of Albay and CIRCA, 2010). Exemplary DRR policies initiated in Albay, such as the institutionalisation of a permanent disaster management office (the Albay Public Safety and Emergency Management Office, APSEMO), are now being rolled out across the country.

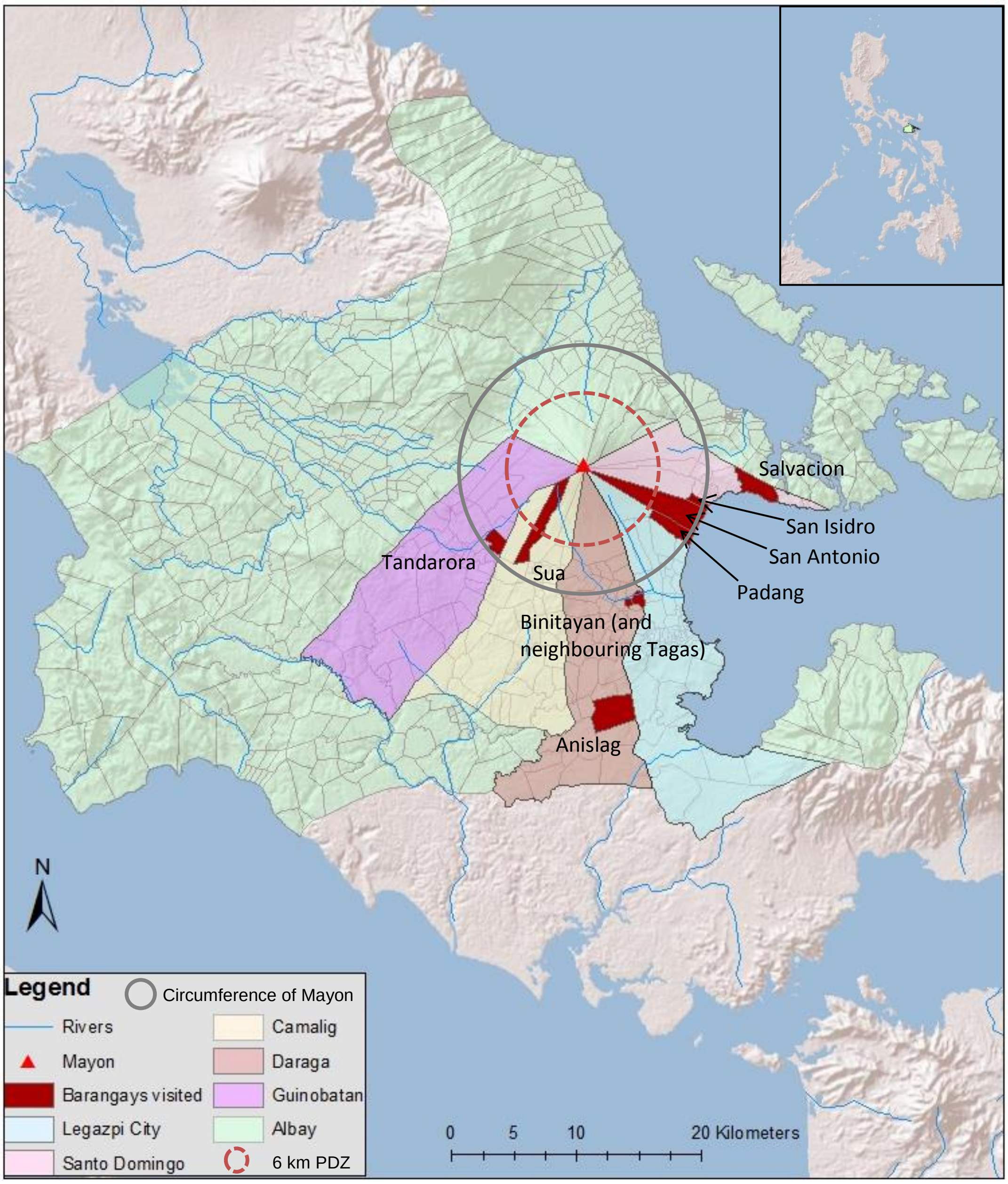


Figure 6.1 Replica of Figure 3.3: Location of the Municipalities, including Legazpi City, and the Barangays visited in October and November 2012. The grey circle represents the approximate circumference of Mayon volcano and the dashed red circle is the 6km radius permanent danger zone (PDZ). Source of data: Phil GIS (2013).

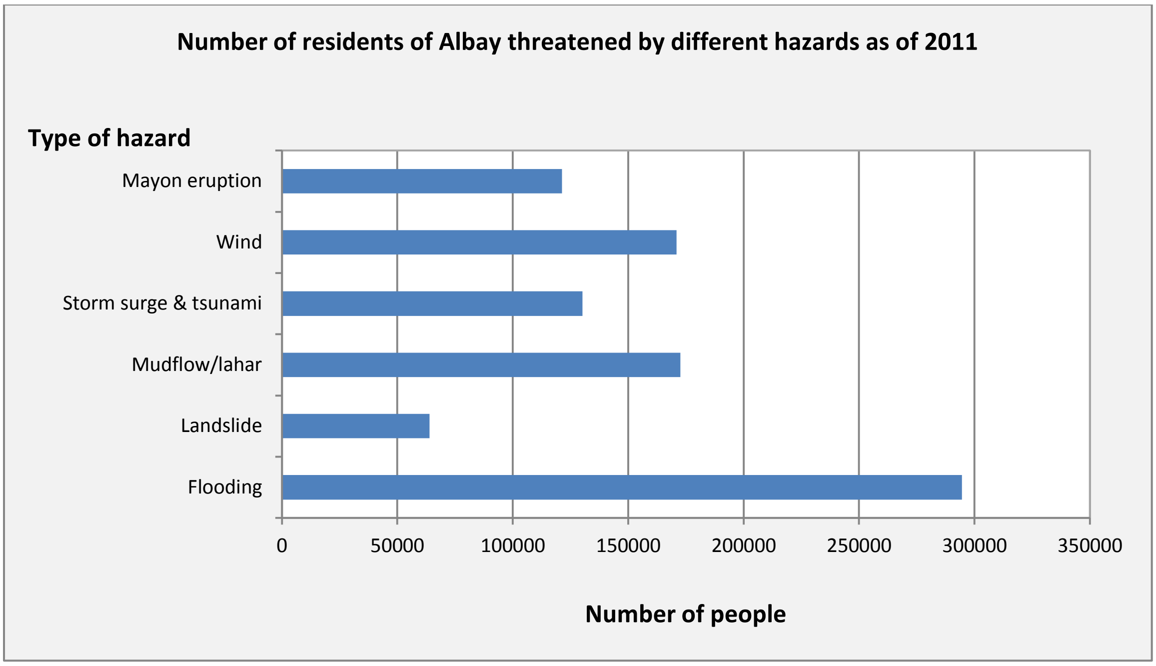


Figure 6.2 Population exposure by hazard type in Albay. Source of data: APSEMO (2011).

Mayon volcano is classified as a stratovolcano and its slopes are laden with eruption deposits comprised of lava, pyroclastic and lahar flows as well as ashfall (Ramos-Villarta et al., 1985; Fano et al., 2007). The volcano stands at a height of 2462m and has a diameter of 20km and a circumference of 63km, encompassing the towns of Santo Domingo, Malilipot and Camalig (Ramos-Villarta et al., 1985). The angle of the slope is 35-40 degrees from the summit down to 2000m before changing to 22 degrees between 200m and 500m and finally five degrees below 500m (Punongbayan, 1985). PHIVOLCS has assigned a 6km permanent danger zone around the volcano: an area of no entry when the volcano reaches alert level 1 (see PHIVOLCS, 2001; Figure 6.1) – extended to 7km in the south where the crater lip is low (Orense and Ikeda, 2007).

From the assimilation of the major sources of historical eruptions available, Mayon appears to have erupted 54 times over the historical record (from 1616 – 2010; see Appendix F) or 60 times according to Aspinall et al. (2011). Its most violent eruption killed 1,200 and destroyed several towns (Aspinall et al., 2011). The volcano poses an ongoing threat to the population of 1 million people living across the seven municipalities and two cities around the volcano (PHIVOLCS, 2007a). Many of the historical eruptions have produced pyroclastic flows and lahars that have devastated populated areas at the base of the volcano (Ramos-Villarta et al., 1985; Catane et al., 2005; Aspinall et al., 2011). Historical eruptions have typically been basaltic-andesitic in nature (Ramos-Villarta et al., 1985; Paguican et al., 2009; GVP, 2013) and have been recorded at magnitudes as great as 4 on the Volcanic Explosivity Index (VEI, Newhall and Self, 1982; see Figure 6.3). Many residents are reliant upon the fertile slopes of Mayon volcano for their livelihoods, as the dominant livelihood at Mayon is agriculture and fishing (Usamah and Haynes, 2012).

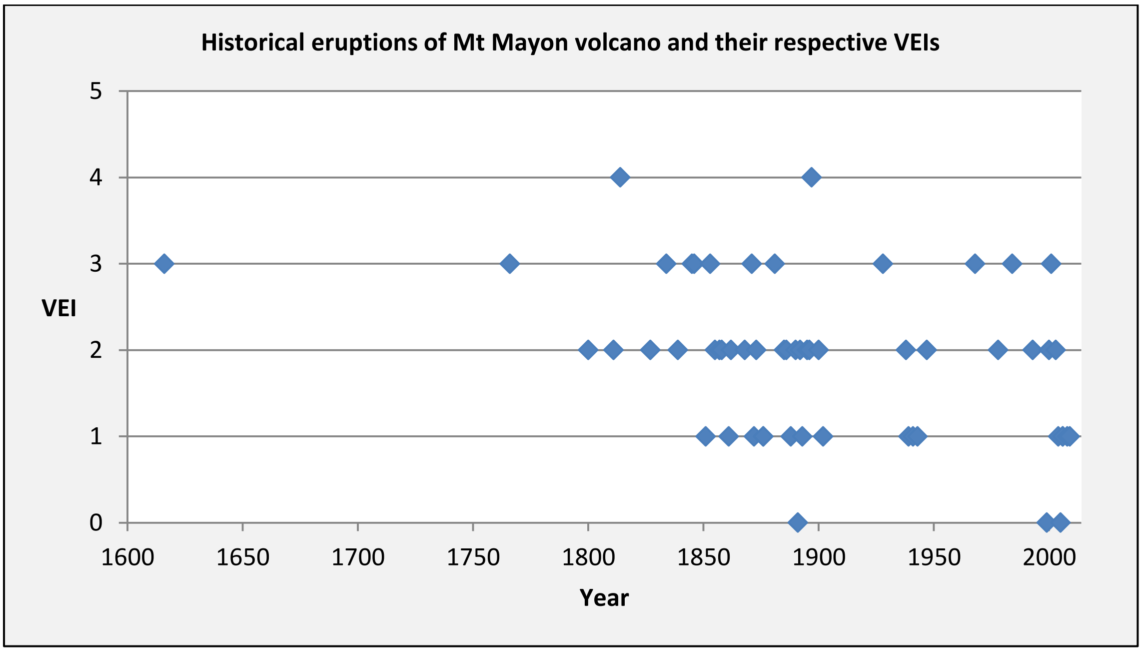


Figure 6.3 Historical eruptions of Mayon volcano (1616 – 2010). Data sources: Rodolfo et al. (1989); Ramos-Villarta et al., (1985); Catane et al. (2005); PHIVOLCS (2008a); GVP (2013).

The climate around Mayon belongs to the Type II climate, which has no significant dry season but a very pronounced maximum precipitation from October/November to January (Okkerman et al., 1985; Arguden and Rodolfo, 1990). The northeast monsoon (October to late March) and southwest monsoon (July to September) bring heavy rain to the area. Most of the rain is, however, brought by tropical cyclones (typhoons and storms) between July and November; these can approach from the South China Sea or the Pacific Ocean (95% originate from the Pacific) and generally travel northwest (Bankoff, 2003). Another source of rainfall is from the Inter-Tropical Convergence Zone (ITCZ), which lies south of the equator from December to February, migrating northward from March and reaching its northernmost position (north of the Philippines) in August and September (Yumul et al., 2011). The climate is also periodically affected by the El Niño Southern Oscillation (Bankoff, 2003; Yumul et al., 2011), which brings increased rainfall to the archipelago during La Niña (Bankoff, 2003).

Since 1993, APSEMO has systematically recorded disasters which have occurred in the province. Figure 6.4 illustrates the dominance of tropical cyclone related disasters during this short period, with Reming being the most devastating disaster to have occurred over this 18-year record. Given the wet climate and high incidence of typhoons it is unsurprising that lahars are a common occurrence during eruptions and post-eruptions. Lahars are deemed to be the most destructive and persistent hazards at Mayon: they bury buildings and infrastructure, block drainage, raise river beds and cause flooding into adjacent areas of low elevation (Catane et al., 2005). Lahars also affect the more distal populations owing to their run-out lengths. They are a major hazard to the populations surrounding Mayon volcano, including the provincial capital.

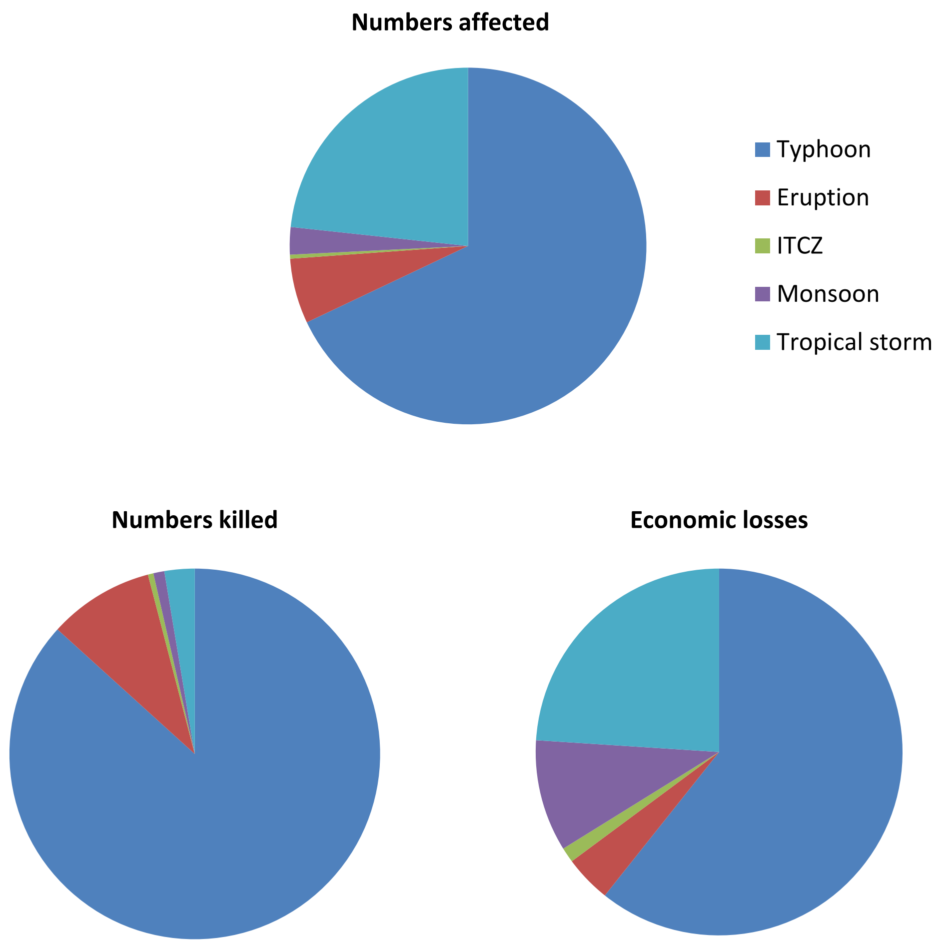


Figure 6.4 The number of Albay residents affected and killed by disaster and the economic losses by disaster. ITCZ is the Intertropical Convergence Zone, which bring heavy rainfall to the province. The pie charts represent the proportion of people or cost per the disaster type. The data reflect the period between 1993 and 2011. Source of data: APSEMO (2012).

### 6.2.1 Lahar hazard at Mayon Volcano

The term 'lahar' (originally Indonesian) is widely used in the volcanological and geological literature as a synonym for 'volcanic mudflow or debris flow' (Vallance, 2005). 'Lahar' has been used to describe both the phenomenon itself (the process of flow) as well as the deposits left by the flow (Rodolfo and Arguden, 1991). For the purposes of this research, the term lahar is used in agreement with Rodolfo and Arguden, 1991, Lavigne et al. (2000) and Vallance (2005) in their adoption of the definition proposed by Smith and Fritz:

> a general term for a rapidly flowing, gravity-driven mixture of rock debris and water (other than normal streamflow) from a volcano (1989: 375).

A lahar event can vary in size and speed with time and distance downstream and may comprise pulses and one or more flow phases, including debris-flow, hyperconcentrated-flow and stream flow phases (Lavigne et al., 2000; Figure 6.5). These phases reflect the fact that the amount of water and rock debris lahars carry is constantly changing (Catane et al., 2005; USGS, 2013). A hyperconcentrated flow typically has a sediment concentration from 20% to 60% by volume and 40% to 60% by weight and is intermediate between debris flow and streamflow (see Lavigne et al., 2000). A debris flow has high viscosity and shear strength, owing to the high concentration of poorly sorted solid content, allowing it to carry large boulders in suspension and flow at higher velocities than Newtonian fluids (Catane et al., 2005). A typical debris flow sediment concentration is in excess of 60% by volume and 80% by weight (Lavigne et al., 2000); therefore, debris flows tend to be more destructive than hyperconcentrated flows.

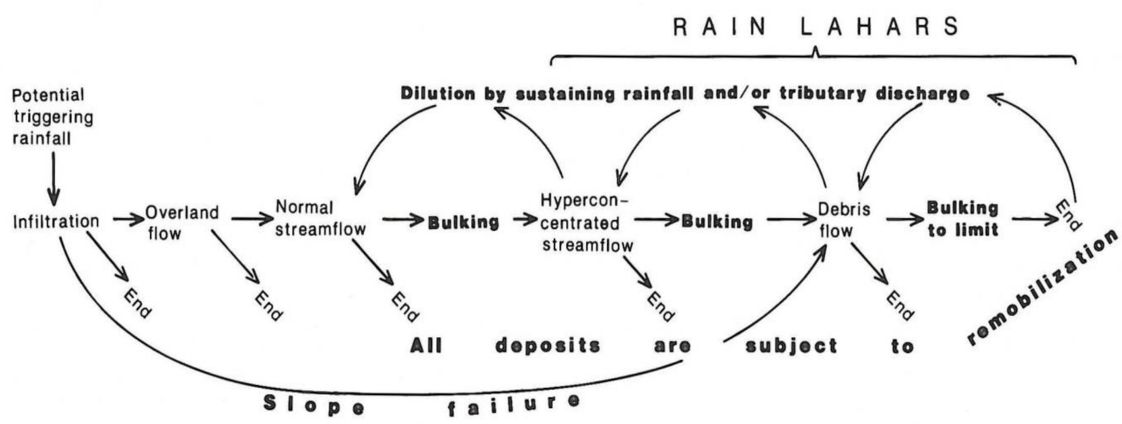


Figure 6.5 Schematic diagram for the generation of rain lahars and changes of state. Dilution can reverse the sequence of streamflow to debris flow and it is possible for a lahar to go through the sequence more than once. The process of lahar genesis is driven by the magnitude and intensities until the debris flow attains the maximum soil content (around 90 wt%). Source: Rodolfo and Arguden (1991: fig. 12: 84; original caption adapted).

Lahars of hyperconcentrated and debris phases can be both erosional and depositional (Lavigne et al., 2000). When a lahar discharge exceeds capacity of the channel, major avulsions occur along channel bends and constrictions (Umbal, 1986; Lavigne et al., 2000). These avulsions are can often be particularly devastating owing to the fact that people may be hit unexpectedly.

A lahar can be classified as syn-eruptive (primary), post-eruptive (secondary) or unrelated to eruptions (non-eruptive; Vallance, 2005). Studies related to Mayon have typically referred to lahars either primary (hot) or secondary (cold) lahars (Rodolfo, 1986; Umbal, 1986; Catane et al., 2005). Mayon is an active volcano, so for the purposes of this study the terms syn- and post-eruptive are used. The use of the term 'secondary' is restricted to the product of multi-hazard interactions. Table 6.1 presents a history of lahars at Mayon volcano. The lahars induced by Reming are the most devastating to have occurred since the 1875 event.

During many of Mayon's eruptions, lahars were generated either by storms or from very localised heavy rainfall owing to eruption updrafts of moist surface air that condense to form rainfall (Rodolfo, 1989). The typical mechanism for lahar formation at Mayon is 'intense' and 'prolonged' rainfall, as a consequence of monsoon rains or the passage of a typhoon in the vicinity of the volcano (PHIVOLCS et al., 2006a; Paguican et al., 2009). The heavy rains cause water saturation and overland surface flow (see Figure 6.5), which can cause severe erosion and transportation of material downslope (Okkerman et al., 1985). In unconsolidated deposits, water saturation can cause mass flow on steep slopes, but stream flow is by far the more important mechanism for lahar genesis on Mayon Volcano (Okkerman et al., 1985).

Table 6.1 History of lahars at Mayon Volcano. The data represent those events that were described or interpreted as being associated with lahar. Undoubtedly many smaller events have occurred between these dates, reflected by the fact that there are more events recorded in the last few decades owing to detailed studies and improved observations. It is indicated whether the event is classed as a syn-eruptive (syn-E) or post-eruptive (post-E) event.

| ***Type*** | ***Date*** | ***Description of lahar*** | ***Reference*** |
|---|---|---|---|
| Post-E | 1766: 23rd - 24th October | A destructive non-volcanic lahar - occurred three months after the last eruption. Heavy typhoon rains triggered the lahars. Town of Malinao was completely destroyed, and Cagsaua, Budiao, Guinobatan, Ligao and Polangui suffered considerable damage. Coconut and other trees were buried up to their crown. Casualties amounted to 30 in Malinao and 19 in Albay (Legazpi). | Ramos-Villarta et al. (1985) |
| Syn-E | 1814 | Torrential rains were generated with the eruption clouds, and resulting lahars buried the villages of Bubulusan, Cagsaua, and Budiao to depths of 10-12m. Total death toll for all villages was estimated to be 1200. Large parts of Ligao, Guinobatan, Libog, Tabaco, and Tiwi were reportedly 'burned and destroyed', but damage in those areas was mostly likely from lahars and tephra fall. | Ramos-Villarta et al. (1985) |
| Syn-E | 1827-1828: June to February | 500m column of fire for several days; lahars triggered by heavy rains on southwest slope, especially near Camalig. Thousands left homeless (probably due to all impacts of eruption). | Ramos-Villarta et al. (1985) |
| Syn-E | 1834-1835 | More or less continuous eruption of 'lava'; on or before 5th May 1935 this pyroclastic flow (?) activity was succeeded by minor eruptions of ash and lapilli, with great steam clouds and strong thunder. The airfall was in turn succeeded by numerous lahars. | Ramos-Villarta et al. (1985) |
| Syn-E | 1845: 19-20 or 21 January | Explosive pyroclastic eruptions and heavy ashfall. Accounts of 'red hot sand' and 'lava flows running down the ravines' probably refer to pyroclastic flows and subsequent lahars. | Ramos-Villarta et al. (1985) |
| Syn-E | 1853: 13 July - 26 August | Major eruption; on July 27 a major lahar, as much as 4m deep in the Nasisi River, changed the course of that river and covered large areas of Ligao, Oas, and Polangui. | Ramos-Villarta et al. (1985) |
| Syn-E | 1858: January to December | Primarily lava flows but lahars were reported by Neumann van Padang (1953). | Ramos-Villarta et al. (1985) |
| Syn-E | 1862 | A minor ash eruption with lahars (Neumann van Padang, 1953). | Ramos-Villarta et al. (1985) |
| Syn-E | 1868: 17 December | Ash cloud eruption and minor flow of red hot rocks; lahars reported. | Ramos-Villarta et al. (1985) |
| Post-E | 1875: November | Heavy rain triggered lahar (two years since previous eruption) killed 1500 people. Most comparably devastating event to the 2006 Typhoon Reming lahars. | Ramos-Villarta et al. (1985) |

| | | | |
|---|---|---|---|
| Post-E | 1881-1882: 6 July to August | Long eruption that began with ash and lappili; lahars occurred repeatedly throughout most of 1881 and 1882, due to the fact that the eruptive event lasted 13 months, feeding ash to the slopes. | Ramos-Villarta et al. (1985) |
| Post-E | 1886-1887: 8 July to 10 March | Long eruption of lava; Lahars began in March 1887 and continued for more than a year. | Ramos-Villarta et al. (1985) |
| Syn-E | 1893: 4 - 23&31 October | Minor ash, lapilli, bombs, lavas and lahars descended the eastern slopes. | Ramos-Villarta et al. (1985) |
| Syn-E | 1895: 20 July - August and November 25 - 26 | Minor ash eruption and lahar. Lightning and an "emission" of rainwater from the summit. | Ramos-Villarta et al. (1985) |
| Syn-E | 1896: 31 August - 27 September | Another period of minor ash and lava eruptions, and minor lahars (Coronas, 1898). | Ramos-Villarta et al. (1985) |
| Syn-E | 1897: 4 June - 23 July | A hot lahar passed down the Basud River (Sto. Domingo) just after the eruption, and another hot lahar descended the ENE slope one month after the eruption. Other post-eruption lahars caused major damage in Camalig. The violence of the eruption left a low gap in the east rim of the crater, a gap which persisted until 1947 and which directed several eruptions toward Sto. Domingo. | Ramos-Villarta et al. (1985) |
| Syn-E | 1900: 1 - 6 March | Ash and lapilli. A hot lahar, 750m wide and 7m deep, flowed slowly down the Basud River and upon reaching the sea, formed large clouds of steam. | Ramos-Villarta et al. (1985) |
| Syn- or post-E? | 1902 | Minor ash eruption with lahars, or just post-1900 eruption lahars (historical record is unclear). | Ramos-Villarta et al. (1985) |
| Post-E | 1915 | Large non-volcanic lahars or "floods" occurred 15 years after eruptions in 1900 and 1902 affected Camalig (southeast) and Bonga and Tabaco (northeast) (Newhall, 1977). | Ramos-Villarta et al. (1985) |
| Post-E | 1930: March (?) | Rain-triggered lahars | Ramos-Villarta et al. (1985) |
| Syn-E | 1968: 20 April - 20 May | Vulcanian eruption; numerous lahars during and after the eruption. | Ramos-Villarta et al. (1985) |
| Post-E | 1981: 30 June | Typhoon triggered lahars killed 40 people [weather event actually classed as Tropical Storm – Daling (Kelly)]. | Ramos-Villarta et al. (1985) |
| Syn- and post-E | 1984: 9 September - 6 October | Vulcanian eruption; numerous lahars during and after the eruption. | Ramos-Villarta et al. (1985) |
| Post-E | 1985 - 1989 | Periodic lahars owing to periods of heavy rain and typhoons. | Rodolfo and Arguden (1991) |

| | | | |
|---|---|---|---|
| Syn-E | 1993: 3 March | Smell of sulphur noted five minutes prior to arrival of lahar at 15:30. Knee-deep and warm (but not boiling). Little rainfall. | GVP (2013) citing PHIVOLCS |
| Post-E | 1995: 2 November | Typhoon Rosing (Angela) triggered lahars. | APSEMO (pers. communication) |
| Post-E | 1998: 21-22 October | Typhoon Loleng (Babs) triggered typhoons. | APSEMO (pers. communication) |
| Syn-E | 2000: 3 March | Lahar activity | Catane et al. (2005) citing Bornas et al. (2000) |
| Post-E | 2001: 21 November? | Lahar triggered after several days of heavy rainfall. Unclear if date of reporting reflects date of lahar, therefore this event is not included in the lahar rainfall analysis in Chapter 8. | GVP (2013; citing PHIVOLCS) |
| Post-E | 2004: 1-2 December | Typhoon Yoyong induced lahars. According to a news report, strong rains brought by typhoon Yoyong in the Philippines caused lahars to flow down the stream channels of Mayon, particularly in the Padang settlement, and Legazpi City (~14 km SE of the volcano's summit). The Provincial Disaster Management Officer stated that the lahars would not cause damage to homes or rice fields, and that villagers residing near the volcano were not asked to evacuate. | GVP (2013; citing ABS-CBN News |
| Post-E | 2006: 27 September | Typhoon Milenyo (Xangsane) brought small lahars to Padang. | PHIVOLCS (2007b) |
| Post-E | 2006: 30 November | Typhoon Reming lahars killed 1266 people. | Numerous sources made reference to throughout Chapter 7 |
| Post-E | 2011: 25-26 July | Tropical depression Juaning (Nock-ten). One resident (Maipon) indicates that lahars occurred from 6am to 2pm on 25 July, initial flows dumped sediments on the northern portion of the lahar field but shifted south to the barangay road between 8am and 10am. But, rainfall at Legazpi station not particularly heavy until the evening of the 25th and into the 26th - did lahars occur on the 26th? | PHIVOLCS (2011a) |

Rodolfo and Arguden (1991) describe 'a typical major lahar, such as the one triggered by Typhoon Rosing [Maury] 3 years after the [1984] eruption' as lasting anywhere between several hours to two days and being mainly of a hyperconcentrated streamflow phase, interspersed with pulses of debris flow, each typically lasting several minutes to one hour, with velocities of three to six metres per second (see references within Rodolfo and Arguden, 1991).

Whilst rainfall is the main trigger of Mayon lahars, the availability of eruptive products plays a major role in the mobilisation and deposition of lahars (PHIVOLCS et al., 2006a). It is this abundance of loose debris on the slopes, along with conditions for triggering, that results in volcanic debris flows being often a magnitude larger than debris flows in other settings (Vallance, 2005). The initiation point for lahars is the upper to middle slopes, where loose and newly deposited pyroclastic materials are located and, when mobilised by heavy rains, flow along gullies and spread out to leave thick deposits and depositional fans on the lower slopes (Catane et al., 2005). During eruptions, lahar initiation and genesis are not only governed by the prevailing weather, but also by the strength of the explosions, and by the size and duration of an eruption column (Arguden and Rodolfo, 1990). In spite of the almost perfect symmetry of Mayon volcano, processes of aggradation and degradation are uneven (Rodolfo and Arguden, 1991). Lava, pyroclastic flows and lahars form discrete deposits (Paguican et al., 2009) and, during quiescent periods, erosional and depositional processes vary, even between closely spaced channels (see Rodolfo and Arguden, 1991).

During an eruption, hot lahars are often larger, debris laden and more destructive that those that occur in post-eruption settings Catane et al. (2005). It is the typhoon related post-eruption lahars, however, that have caused more human fatalities – partly due to their size but also perhaps a reflection of the declining volcanic awareness of Mayon residents (Umbal, 1986). The lahar history at Mayon demonstrates that lahars are a relatively frequent occurrence, interspersed with particularly devastating events. The case study of Reming therefore presents the opportunity to analyse a commonly occurring hazard but with a less commonly observed impact. Before presenting the findings of the case study analysis, it is necessary to mention the sources of information used in this analysis.

## 6.3 Review of data collected for case study analysis

The data were collected via four means: peer-reviewed literature, semi-structured interviews, observations and secondary data analysis (including the analysis of internal reports collected in the field). Each of these data sources are briefly discussed below.

### 6.3.1 Peer-reviewed literature

A small number of forensic analyses of the occurrence and impact of the Typhoon Reming lahars have been published; these range from the analysis of the occurrence and inundation paths of the lahars (Orense and Ikeda, 2007; Paguican et al., 2009), to a focus upon the meteorological conditions during and shortly before the event (Yumul Jr et al., 2008; Yumul et al., 2011). Others have focused more upon the long-term risk reduction measures (Usamah and Haynes, 2012). To date, however, there has been no analysis of this disaster from the perspective of multi-hazards. Furthermore, there are contradictions and controversies within the literature, including disagreements over the timing of the lahars (compare Orense and Ikeda, 2007, with Paguican et al., 2009) and claims that residents chose not to evacuate (Paguican et al., 2009). There is also an absence of perspectives from NGO staff in the existing literature.

Given the gaps and contradictions in the literature, it was essential to visit the site and speak with the key stakeholders involved in the event to ascertain what occurred. Most of the literature cited eye witness accounts as a source of their information, implying that collecting information from communities who were affected by the lahars is a key tool in understanding this disaster.

### 6.3.2 Semi-structured interviews

Semi-structured interviews were conducted with those affected by the disaster (communities) and those involved prior to, during and since the disaster in terms of hazard assessment and response: scientists, local government and NGOs (collectively referred to as DRR stakeholders). The details of these interviewees are presented in Table 6.2.

The interview guide for the stakeholders can be viewed in Appendix C. Questions varied depending upon interviewees' knowledge of the disaster. In order to ensure anonymity, the NGOs and local government agencies have not been disclosed as, given the small size of the local agencies, it would make individuals too readily identifiable. The NGO staff interviewed are described by their job title, but the three local government disaster management staff required the generic titles of 'LG (local government) Disaster Manager' as anything more explicit would have compromised their anonymity. The scientific organisations are larger in size making ensuring anonymity easier, but these participants are referred to only by their organisation and scientific category (e.g. geologist) and not their job title (see Table 6.2). Table 6.3 provides background to the government scientific agencies that were interviewed during the study.

The details of the community members were presented in Chapter 3 but can be viewed in greater detail in Appendix G. The interview guide used to conduct these interviews can also be viewed in Appendix C. Interviews were conducted in the municipalities of Guinobatan, Camalig, Daraga and Santo Domingo (Figure 6.1), which were all badly affected by lahars.

Table 6.2 List of DRR stakeholders interviewed. Those with whom the case study was discussed to the greatest extent are in bold and they represent the source of the majority of stakeholder derived information collected about this event.

| Group | Name | Level | Location | Date of interview | In organisation during Reming | Signed consent | Recorded |
|---|---|---|---|---|---|---|---|
| ***Scientists*** | **International volcanologist** | **International** | **Santo Domingo, Albay** | **13/10/2012** | **N** | **Y** | **Y** |
| | **Academic Geologist 1** | **N/A** | **Quezon City, Manila** | **17/10/2012** | **Y** | **Y** | **N** |
| | Academic Geologist 2 | N/A | Quezon City, Manila | 04/11/2012 | Y | Y | N |
| | **MGB Regional Geologist** | **Regional** | **Legazpi City, Albay** | **22/10/2012** | **Y** | **Y** | **Y** |
| | MGB National Geologist | National | Legazpi City, Albay | 15/10/2012 | Y | Y | Y |
| | **PAGASA Regional Meteorologist** | **Local** | **Legazpi City, Albay** | **24/10/2012** | **Y** | **Y** | **Y** |
| | **PAGASA STRIDE Team Leader** | **National** | **Quezon City, Manila** | **17/10/2012** | **Y** | **Y** | **Y** |
| | **PHIVOLCS Geologist 1** | **National** | **Quezon City, Manila** | **17/10/2012** | **Y** | **Y** | **Y** Interviewed together |
| | **PHIVOLCS Geologist 2** | **National** | **Quezon City, Manila** | **17/10/2012** | **Y** | **Y** | **Y** |
| | **PHIVOLCS Geologist 3** | **National** | **Quezon City, Manila** | **07/11/2012** | **Y** | **Y** | **Y** |
| | **PHIVOLCS Volcanologist 1** | **Local** | **Legazpi City, Albay** | **21/10/2012** | **Y** | **Y** | **Y** |
| | PHIVOLCS Volcanologist 2 | National | Quezon City, Manila | 07/11/2012 | Y | N | Verbal consent |
| ***Local government*** | **LG Disaster Manager 1** | **Local** | **Santo Domingo, Albay** | **22/10/2012** | **Y** | **Y** | **Y** |
| | **LG Disaster Manager 2** | **Local** | **Legazpi City, Albay** | **23/10/2012** | **Y** | **Y** | **Y** |
| | **LG Disaster Manager 3** | **Local** | **Legazpi City, Albay** | **31/10/2012** | **Y** | **Y** | **Y** |
| | **OCD (Office of Civil Defence) Regional representative** | **Regional** | **Legazpi City, Albay** | **24/10/2012** | **N** | **Y** | **Y** |
| ***NGOs*** | INGO A DRR Specialist | International | Makati City, Manila | 18/10/2012 | Y | Y | Y |
| | INGO A DRR Country Programme Adviser | International | Makati City, Manila | 18/10/2012 | Y | Y | Y |
| | INGO B Humanitarian Programme Coordinator | International | Quezon City, Manila | 19/10/2012 | Y | Y | Y |
| | **Local Heath Volunteer** | **Local** | **Santo Domingo, Albay** | **14/10/2012** | **Not known** | **Y** | **N** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Local NGO A R1 (Community organiser)** | **Local** | **Legazpi City, Albay** | **26/10/2012** | **Y** | **Y** | **Y/N Informal interview (26/10/2012) and interview with colleague above on 27/10/2012** |
| | **Local NGO A R2 (DRR point person) [Local NGO Ph2 in Chapter 4]** | **Local** | **Legazpi City, Albay** | **27/10/2012** | **Y** | **Y** | **Y** |
| | **Local NGO B R1 (Programme staff)** | **Local** | **Daraga, Albay** | **25/10/2012** | **Y** | **Y** | **Y/N Informal interview and interview with colleague below** |
| | **Local NGO B R2 (Executive Director)** | **Local** | **Daraga, Albay** | **25/10/2012** | **N** | **Y** | **Y** |
| | **Local NGO C (Researcher)** | **Local** | **Legazpi City, Albay** | **24/10/2012** | **Y** | **Y** | **Y** |
| | **National NGO (Deputy Executive Director)** | **National** | **Quezon City, Manila** | **15/10/2012** | **Y** | **Y** | **Y** |

Table 6.3 Government scientific agencies involved in the research.

| ***Agency*** | ***Department*** | ***Mandated hazards (hazard assessments and monitoring)*** |
|---|---|---|
| *Mines and Geoscience Bureau (MGB)* | Department for Environment and Natural Resources | Rainfall induced landslides and flood maps. |
| *Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)* | Department for Science and Technology | Weather and climate; flood forecasting; astronomy. |
| *Philippine Institute of Volcanology and Seismology (PHIVOLCS)* | Department for Science and Technology | Volcanoes, earthquakes, and associated hazards (including earthquake induced landslides); tsunamis. Lead on the multi-hazard mapping project (READY). |

During the discussion, the NGOs, scientists and local government interviewees are collectively referred to as DRR stakeholders, whereas the victims of lahar are described as either communities or residents. Whilst a balanced view of interviewees' responses is endeavoured, it transpired during the interviews that certain participants were more knowledgeable of the disaster due to their having experienced it, been involved in the response or having studied the event since. As a consequence these interviewees are referred to more often than other interviewees, which reflects the availability of information about the event rather than any bias.

### 6.3.3 Observational techniques and secondary information collected in field

In addition to the interviews described above, understanding and interpreting the case study was also reliant upon the researcher's observations and the available secondary material. Photographs and field notes regarding the remains of the impacts of each of the barangays visited were taken. The researcher was also invited to attend two forums regarding research on flood risk in Manila, where she was able to observe the heated interaction between academic and government scientists and between local and international scientists. Information on the events attended is presented in Appendix A.

Internal reports from organisations interviewed were collated and reviewed in order to better understand this disaster from multiple perspectives (see references within Chapters 7 and 8). Rainfall data were sourced from PAGASA for the purpose of comparing this with historical lahar events (see Chapter 8). The data reflect the period between the beginning of 1978 and the end of August 2012 (the latest record available) and are limited to this period owing to their cost.

## 6.4 Summary

Albay is a multi-hazardous province and lahars are a persistent threat to the populations surrounding the volcano, with post-eruption lahars having tended to cause the most deaths. The 2006 Typhoon Reming lahars disaster offers the opportunity to explore a case of one hazard triggering another in the context of this multi-hazardous environment (Albay). The case study analysis builds upon the four key sources of information: semi-structured interviews, secondary data (peer-reviewed literature, internal reports and rainfall data), participant and field observations.

The findings from the case study analysis are presented in Chapters 7 and 8. Chapter 7 presents the analysis of the multi-hazard characteristics of the case and Chapter 8 discusses the current scientific methods adopted for assessing and anticipating this type of multi-hazard event at Mayon.

# Chapter 7: The multi-hazard characteristics of the Typhoon Reming lahars disaster

Chapter 7 presents the findings from the analysis of the Typhoon Reming lahars case study. The chapter begins with a review of notable events leading up to the disaster. This is followed by a narrative of the case study, with particular focus given to (1) the warning and evacuation; (2) the anticipation of the event; and (3) the understanding amongst different stakeholders as to why this disaster included lahar. The analysis comprises the combined findings from the literature, internal reports, field observations and semi-structured interviews that were implemented, with comparisons made between the perceptions of DRR stakeholders (scientists, local government and NGOs) and communities. The chapter concludes with a summary of the multi-hazard characteristics of the Typhoon Reming triggered lahars case study, the key themes that emerged during the analysis and a short reflection on the lessons learnt from this disaster.

## 7.1 Hazards and disasters leading up to Typhoon Reming

The Philippines is one of the most multi-hazardous countries in the world and 2006 exemplified this, with the year beginning with flooding, flashfloods and landslides as a consequent of La Niña (Yumul Jr et al., 2008). A succession of small and medium-sized events relentlessly hit the province of Albay (Figure 7.1) and consequently placed a strain upon the local government[1]. LG Disaster Manager 3 said that the province experienced a series of floods in May or June. In August, residents surrounding Mayon volcano were affected by a minor (VEI 1) eruption of Mayon, which necessitated the evacuation of 95, 926 people (Usamah and Haynes, 2012) or 40,000 people according to Orense and Ikeda (2007).

[1] LG Disaster Manager 3

| | **Guinsaugon landslide** *(17/02)* | | **Tropical Storm Caloy (Chanchu)** *(11/05)* | | **Eruption of Mayon volcano** *(13/07-01/10)* ***Tropical Storm Henry (Prapiroon)*** *(28/07-02/08)* | **Enhanced south west monsoon** | **Typhoon Milenyo (Xangsane)** *(27/09)* | **Typhoons Paeng (Cimaron)** *(27-31/10)* **and Queenie (Chebi)** *(08-12/10)* | **Typhoon Reming (Durian)** *(30/11)* | **Typhoon Seniang (Utor)** *(2/12)* |
|---|---|---|---|---|---|---|---|---|---|---|
| … | Feb | … | May | … | July | August | Sept | Oct | Nov | Dec |
| | *Inundated barangay Guinsaugon, Southern Leyte. Occurred a few days after the heaviest rainfall had occurred and may have also been triggered by an eruption (see Evans et al., 2007; Guthrie et al., 2009).<br>Relevance: demonstrated complexity of determining multi-hazard interactions, along with the risk from large mass movement failures, only 10 months before the typhoon Reming lahars.* | | *Signal # 3 over Albay<br>47,065 people evacuated; 5 injured.<br>[Might reflect the flooding recalled by LG Disaster Manager 3]* | | *On the 13th July incandescent lava fragments appeared to be detaching from the volcanic dome; ash explosions continued throughout August 95,926 people evacuated (Usamah and Haynes, 2012)<br>Henry: Signal # 1 over Albay* | *No information regarding the impact of this on Albay.<br>Enhancement of the south-west monsoon mentioned by Yumul et al. (2008).* | *Signal # 3 over Albay<br>698,460 people affected, 14 killed and 176 injured.<br>Economic damage and power outages.<br>Economic damage PhP 1.7 billion.<br>Largest typhoon to affect Albay in advance of Reming. May have made people complacent (Orense and Ikeda, 2007).* | *Paeng: Signal # 1 over Albay<br>Queenie: No warning for Albay<br>Hit Luzon but there was minimal impact upon Albay* | *Signal # 4 over Albay<br>Typhoon Reming hits Albay and neighbouring provinces.* | *Signal # 2 over Albay. Minimal cumulative rainfall meant only muddy streamflows were observed along identified river channels affected during the Super Typhoon Reming event (PHIVOLCS, 2006).* |

Figure 7.1 Timeline of disasters triggered by natural hazards during 2006 in the Philippines. Those which did not affect Albay are in grey. The international name for the tropical storms and typhoons are included in brackets after the name used in the Philippines. Source of information: PHIVOLCS (2006a); PAGASA (2006); Evans et al. (2007); Yumul et al. (2008); Guthrie et al. (2009); APSEMO (2012).

On the 27th September, the province (along with other parts of Luzon, including Metro Manila) was affected by Typhoon Milenyo (international name Xangsane), which travelled over Albay as a PAGASA public storm warning # 3 storm signal (see Table 7.1). Milenyo caused 14 fatalities in Albay and injured 176 people, but its main impact was economic (1.7 billion PhP; US$ 33.3million APSEMO, 2006a) and infrastructure (power) damage (Yumul Jr et al., 2008). Typhoon Milenyo did not generally trigger lahars, apart from in a few isolated cases, but three DRR interviewees[2] stated that Typhoon Milenyo may have increased siltation within the river channels on Mayon, thus making them more susceptible to lahar during Typhoon Reming (see also Orense and Ikeda, 2007; Usamah and Haynes, 2012).

Table 7.1 PAGASA typhoon classification and warning criteria – note that when any Public Storm Warning Signal Number is initially put in effect, the corresponding meteorological conditions are not yet occurring over the locality. The lead time in the subsequent issues of the warning bulletin shortens as the tropical cyclone comes closer. Source of information for table and caption: PAGASA (2013).

| **PAGASA Public Storm Warning Storm Signal Number** | **Wind speed in knots (and km per hour)** | **Lead time of first warning bulletin** |
|---|---|---|
| *#1* | 16 – 32 (30 – 60) | 36 hours |
| *#2* | >32 – 54 (>60 to 100) | 24 hours |
| *#3* | >54 – 100 (>100 to 185) | 18 hours |
| *#4* | >100 (>185) | 12 hours |

Communities were deemed to still be recovering from Typhoon Milenyo[3] when Typhoon Reming arrived on the 30th November. One interviewee[4] said that houses were not yet strong enough to survive another typhoon, whilst the representative of Local NGO C mentioned that they were still assisting people with their recovery from Milenyo (see also Usamah and

[2] PHVIOLCS Volcanologist; LG Disaster Managers 2 and 3
[3] PAGASA Regional Meteorologist said that because people had just had a typhoon they were not well prepared for another.
[4] LG Disaster Manager 1

Haynes, 2012). In general, however, the communities interviewed described very little[5] damage from Typhoon Milenyo:

> *Lahar during Milenyo but not so strong. House not so heavily damaged during Milenyo. Able to fix house after Milenyo.* (Leja, Barangay Lidong)

Power lines were still down and the ability of the local government to warn communities at risk was impaired[6]. Therefore, amongst the majority of the residents interviewed, communities' direct vulnerability was not increased by Typhoon Milenyo, but the ability of the government to communicate and respond to a subsequent event (Reming) was compromised.

## 7.2 Description of the Typhoon Reming lahar disaster and its multi-hazard impacts

On the 30th November 2006, Typhoon Reming (international name Durian) hit the province of Albay. The event was classed as a supertyphoon, owing to maximum sustained winds of 190 kilometres per hour (kph) at its centre and gusts of up to 225 kph (Orense and Ikeda, 2007). Rainfall of 466mm fell between 8am and 8pm, which is almost equal to the average monthly rainfall for November in Albay (486mm; Orense and Ikeda, 2007). The rainfall mobilised lahars of such great volume and length that were described as 'unprecedented in the recent history of Mayon' (Paguican et al., 2009: 846; PHIVOLCS, 2006a: 1). Major flashfloods and lahars occurred in the lower reaches of the southern sector of Mayon (PHIVOLCS, 2006a). The floods and lahars overtopped river channels, breached dikes and cut new paths (up to 100m wide and 15m deep) through communities, rice fields and coconut plantations (Paguican et al., 2009). Given that the lahars were triggered by a typhoon, DRR stakeholders and communities described a number of different hazards that occurred in addition to lahars, including strong

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[5] Edraline said his house was 'tilted' (Barangay Lidong); Gemma's house was affected by minor lahar (Barangay Tandarora)
[6] LG Disaster Manager 2 and 3

wind, landslides, flooding and storm surge[7]. Most of the deaths, however, were caused by the lahars, which killed 1266 people (APSEMO, 2006b). Economic losses (e.g. damage to coconut plantations[8]) were attributed to the wind[9] (Table 7.2).

Typhoon Reming was described as travelling directly through Albay, with one DRR stakeholder stating that the eye of the typhoon passed close to Legazpi City[10] and another emphasising that it was the wall of the eye that passed overhead, which they deemed significant as this brought the most rainfall. However, Figure 7.2 indicates that the typhoon eye tracked about 30km north of Mayon volcano. Table 7.2 also indicates that the typhoon brought havoc to most of the Bicol region, but the comparatively high number of deaths in Albay emphasises the significant impact of the lahars in Albay compared with the impact of the typhoon in other provinces.

In Albay, Legazpi City was badly flooded and, owing to debris littering the runway, the airport was closed for a couple of days (Orense and Ikeda, 2007). Many of the DRR stakeholders were themselves affected by flooding and so were not able to immediately respond to the lahar victims[11]. The compounding effect of the strong winds and poor visibility during the typhoon meant that rescue workers could do little to help people affected by the lahars in the immediate aftermath (see also Orense and Ikeda, 2007). This was made more difficult by the fact that the lahar was very difficult to cross:

> *'..the problem is even rescue workers cannot do anything because the wind velocity's enormous and the area really is difficult to cross, no vehicle can be used, and the*

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[7] The following interviewees mentioned the additional hazards that occurred during the event: LG Disaster Manager 2 (all the hazards mentioned); DRR Point Person (Local NGO A) (flooding); Local Health Volunteer (landslides); interviews in Barangay Salvacion (flooding, wind and landslides); PHIVOLCS Geologist 2 (wind); PHIVOLCS Volcanologist 2 (wind) ; Renaldo in Barangay Lidong (combination of wind and rain); Maria in Barangay Tandarora (flooding and wind); interview in Anislag (strong wind); interview in Binitayan (flash flood); Perla in Barangay Sua (wind and heavy rain); Jerry in Barangay San Isidro (wind and flooding).

[8] According to International Volcanologist, these took years to recover.

[9] PHIVOLCS Geologists 1 and 2

[10] MGB Regional Geologist; PHVIOLCS Volcanologist 1

[11] LG Disaster Manager 3; DRR Point Person (Local NGO A)

*typhoon is so strong that the visibility is too close so … it's very dangerous to go out during that time. It's almost hazy because of the strong wind and rain…'* (PHIVOLCS Volcanologist 1)

These compounding effects highlight the need to consider the combined effect of the different hazards produced during one event. This situation also emphasises the role communities have as first responders to a disaster and that they have to be prepared for when the local government and local NGOs cannot immediately assist.

There was significant damage to mitigation structures from both the typhoon and the lahars: flood controls, seawalls, drainage structures and lahar mitigation structural damage amounted to PhP 1.5 billion[12]. Reming also caused widespread power outages in the province and knocked out telecommunications and transportation networks (Orense and Ikeda, 2007), hindering the communications during and in response to the typhoon. The Philippine Government declared a 'State of National Calamity', which prompted an international relief operation in the weeks and months following the typhoon (NDCC, 2006).

[12] US$1 = PhP46 according to Orense and Ikeda (2007)

Table 7.2 Summary of casualties, evacuees and damage from typhoon Reming across the Bicol region. The difference in the number of deaths recorded by Orense and Ikeda (2007) is in part a reflection of the fact that some classed as missing in the table below will have been assigned to the deceased category at a later date. However, there is still a slight shortfall between the 1266 people recorded by Orense and Ikeda (2007) and the number of deaths recorded in this data. Source: OCD (2006).

| ***Province in Bicol Region (no. of municipalities and barangays)*** | ***Impact on residents*** | | | | | ***Damage*** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***No. of casualties*** | | | ***No. of evacuees*** | | ***No. of houses damaged*** | | ***Agriculture (Philippine Pesos)*** | ***Infrastructure (Philippine Pesos)*** |
| | ***Dead*** | ***Injured*** | ***Missing*** | ***Families*** | ***People*** | ***Partially*** | ***Totally*** | | |
| ***Albay*** *(18 municipalities; 653 barangays)* | 608 | 1,394 | 605 | 6674 | 31, 085 | 78,272 | 96, 879 | 545,221,462 | 569,194,897 |
| ***Camarines Norte*** *(12 municipalities; 237 barangays)* | [No figure] | 2 | [No figure] | [No figure] | [No figure] | 10,689 | 904 | 34, 477,255 | [No figure] |
| ***Camarines Sur*** *(37 municipalities; 917 barangays)* | 9 | 199 | 0 | 5,554 | 29, 439 | 130,391 | 89,383 | 13, 548,816 | [No figure] |
| ***Catanduanes*** *(11 municipalities; 315 barangays)* | 16 | 330 | 0 | 0 | 0 | 24,580 | 14,304 | [No figure] | [No figure] |
| ***Masbate*** *(3 municipalities; 30 barangays)* | 3 | 1 | 1 | [No figure] | [No figure] | 4,909 | 2,854 | [No figure] | [No figure] |
| ***Sorsogon*** *(16 municipalities; 180 barangays)* | 6 | 18 | 3 | 277 | 1,602 | 19,690 | 4,812 | [No figure] | [No figure] |
| **Total (Region wide):** | **642** | **1,944** | **609** | **12505** | **62,126** | **268,531** | **112257** | **593,247,533** | **569,194,897** |

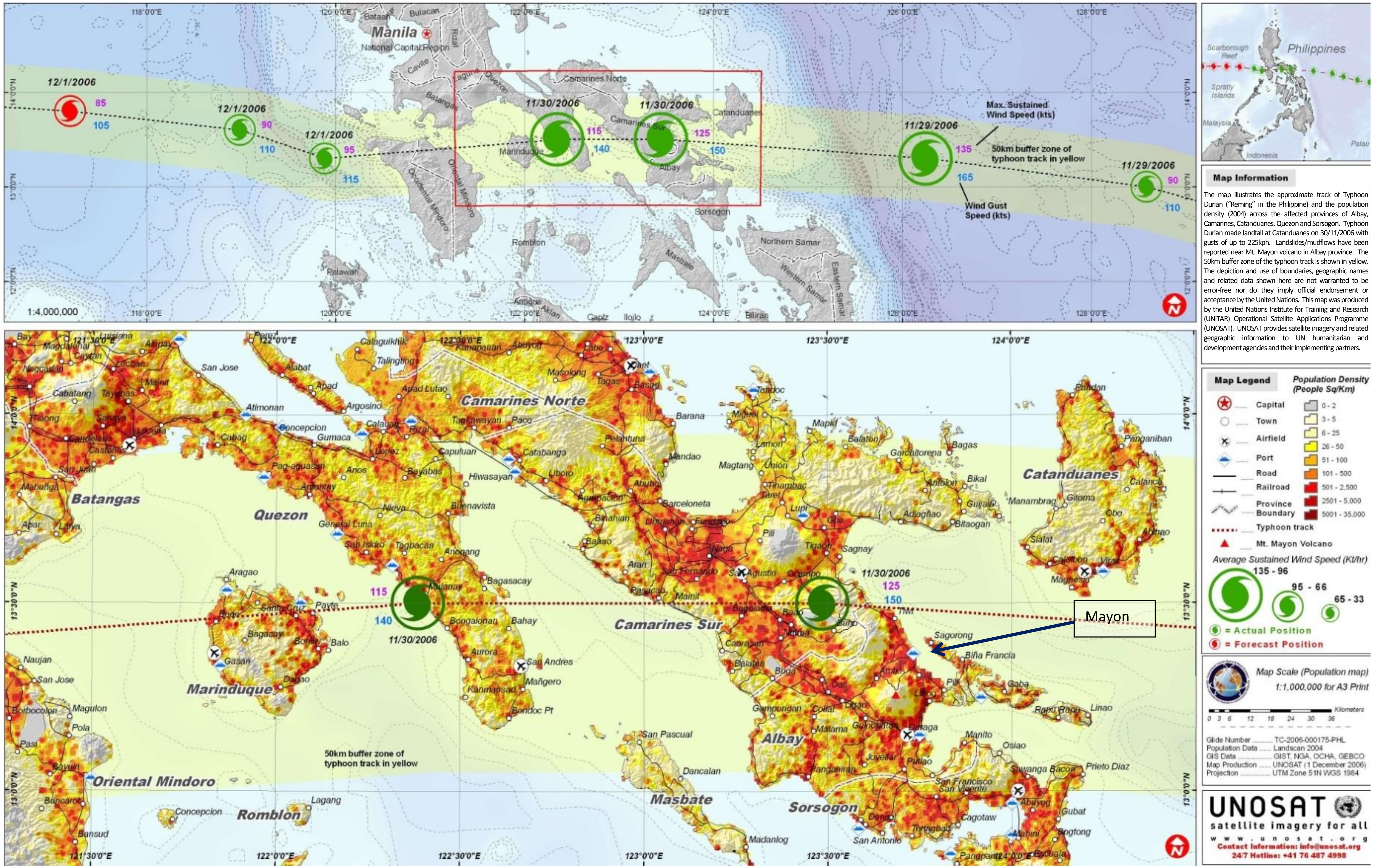


Figure 7.2 Track of Typhoon Reming. Mayon is represented by a small red triangle in the bottom image (labelled for clarity). Source: UNOSAT (2006).

### 7.2.1 Lahar characteristics and impact

The lahars travelled well beyond the 6km PDZ (Orense and Ikeda, 2007; Figure 7.3), burying large areas and causing upstream flooding from debris-choked tributaries (Orense and Ikeda, 2007). As such, there was a spectrum of hazards from flash flooding to debris flow that affected communities residing in both the upper and lower reaches of the channels that dissect Mayon volcano. Figure 7.3 outlines the areas of lahar deposition, the channels that transect Mayon's edifice and the barangays visited during the field visit (as well as the location of Barangay Tagas – the pre-Reming location of the residents interviewed in Barangay Anislag).

In spite of the lahar hazard map indicating that areas were equally prone to lahar around the entire edifice (see Section 7.4.1, Figure 7.14), the lahars were concentrated in the southern sector of Mayon volcano, specifically in the municipalities of Guinobatan, Camalig and Daraga as well as Barangay Padang in Legazpi City and parts of Santo Domingo (Orense and Ikeda, 2007; Paguican et al., 2009; see Figure 7.3). The impact also varied within the southern sector and Guinobatan was one of the hardest hit, with numerous houses buried under two to three metres of lahar (Orense and Ikeda, 2007), and Barangay Padang in Legazpi City was completely destroyed (see Figure 7.4). The description of the specific impact to each of the barangays visited during this trip is contained in Appendix H.

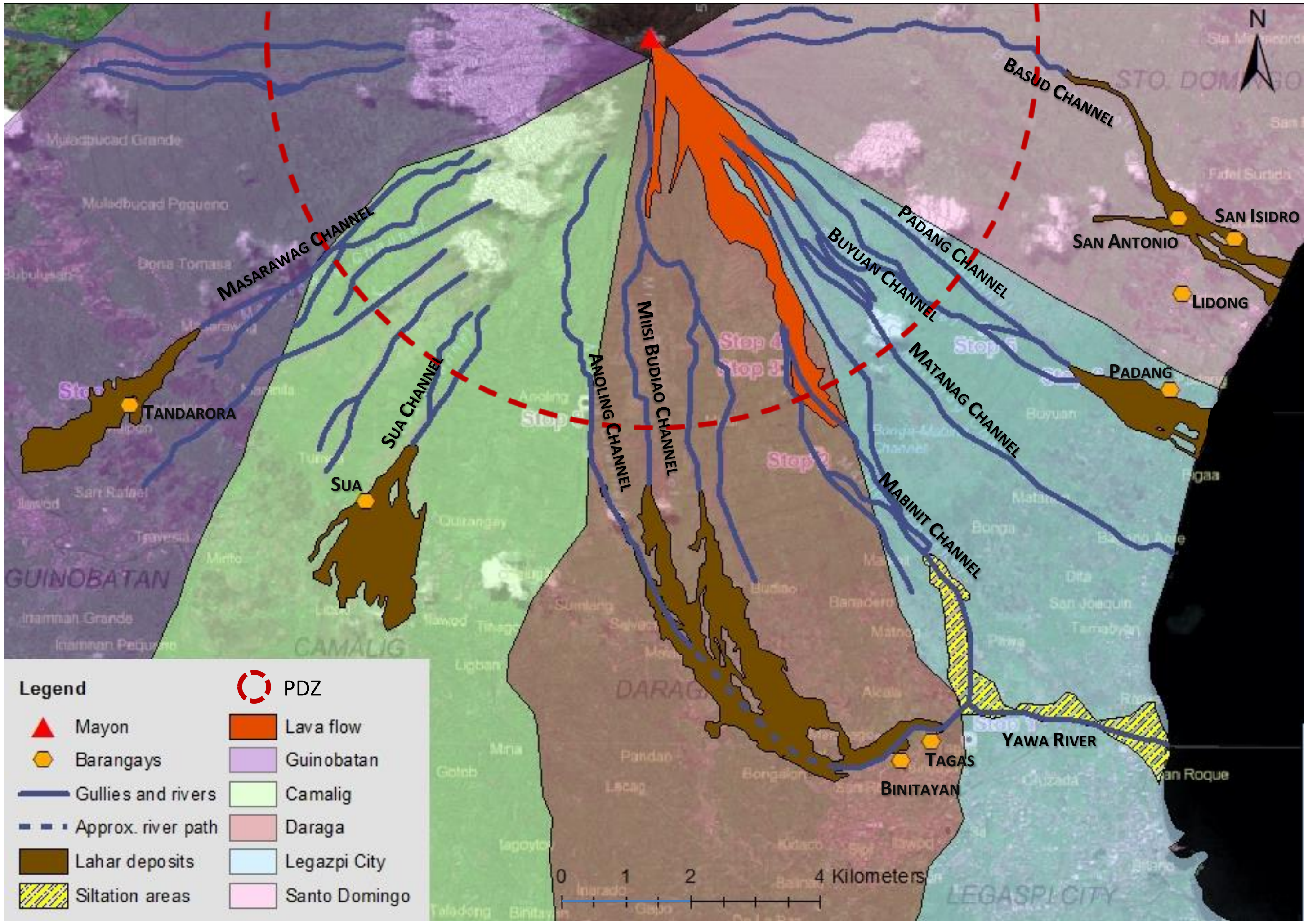


Figure 7.3 Map of the Typhoon Reming lahar deposits, areas of siltation, the 2006 lava flow, the gullies and rivers the lahars tend to follow, barangays and municipalities of interest to the study. The map was created by digital manual tracing of elements of the December 2006 preliminary quick response team deposit map created on SPOT 5 imagery (from May 2005). The original map is still partially visible. Source: PHIVOLCS (2007a).

Figure 7.4 The location of what was once Barangay Padang (October 2012); all the residents have been relocated by the local government owing to the persistent threat of lahars, although some have returned to the area and are living in informal settlements. Source: author's own.

The concentration of lahars in the southern sector of the volcano was a reflection of the recent activity of Mayon volcano. Three PHIVOLCS interviewees described a notch in the south-east edge of the crater, which was created during the 1984 eruption:

> *'there was a notch that was created in south eastern rim of the crater. Then the pyroclastic flows started going that way then they were flowing down these slopes and just eating up the material and by the end of the eruption the flows had produced this huge gully – 300m wide'* (PHIVOLCS Geologist 3)

The deposits from the 1984 and subsequent eruptions (see Appendix F) had therefore been concentrated in the southern sector. The availability of fresher deposits compared with those in the northern sector of the volcano meant that there was more material available for lahar entrainment, owing to the fact that it had not been removed by previous events or stabilised by vegetation growing on the slopes[13] (PHIVOLCS, 2006a). The Reming lahars are thought to be the remobilisation of the 2000-2001 eruption deposits (PHIVOLCS et al., 2007a). There was flooding on the northern slopes of the volcano, which indicates that there was no significant

[13] Academic Geologist 1

difference in the amount of rainfall that fell; so the fact that lahars only occurred in the south further emphasises the influence of previous eruptions on the spatial distribution of lahar exposure in the medium (decadal) term.

The types of lahars varied across and within different river channels. Residents in the upstream communities of Barangays Tandarora and Sua were affected by boulder laden debris flows (Figure 7.5). In contrast, the flows that affected the more downstream residents of Binitayan and Tagas (now resident of Anislag) were hyperconcentrated (likely a result of debulking of the lahar flows), but these also carried some boulders (PHIVOLCS, 2006a) and still caused significant damage (Figure 7.6). However, in general the different flows had different impacts:

> *'the hyperconcentrated flow is not so devastating…it wasn't anywhere near the physical intensity of impact that there was where there was debris flow.'* International Volcanologist

The spatial variation of the types and location of flows thus emphasises the need for hazard assessments and DRR strategies at the community level.

Figure 7.5 Barangay Captain of Tandarora stands next to lahar deposition 3-4 metres high from Typhoon Reming (October 2012). Source: author's own.

Figure 7.6 Ruined homes in Barangay Binitayan, which was downstream of barangays devastated by debris flows but was still devastated by hyperconcentrated flows and some boulder laden flows (September 2010). Source: author's own.

**Multi-hazard vulnerability**

As mentioned above, the disaster was a consequence of multiple hazards and the different impacts of each of these hazards emphasises why vulnerability assessments need to consider the impact of multiple hazards within a single event. Typhoons typically bring strong wind, thus the perception was that concrete homes were less vulnerable than those constructed of indigenous materials (e.g. bamboo, sawalli, cogon and nipa; National Statistics Office, 2007) or improvised materials (e.g. scrap metal; see Figures 7.7 - 7.9). However, some community members were not aware that their concrete homes were also vulnerable because of the lahars:

> *'The most devastating was mud and debris flow and also wind. So we saved a lot of people during landslide, we saved a lot of people during flood, we saved a lot of people during storm surge because they evacuated; but in terms of mudflow they were not evacuated because they were residing in the concrete houses but without knowing…*[that] *even the concrete structures will be destroyed because the turbidity and the strength of that flow will be higher than the flood'* (LG Disaster Manager 2)

Of those who did eventually evacuate, residents in indigenous or improvised homes responded by moving to houses made of concrete as (based upon their past experience of typhoons) they assumed these structures would withstand the winds[14]. However, as pointed out by another DRR stakeholder, these evacuees did not consider the lahars:

> *'The one case of that happened in one community in Daraga…the poor people tend to evacuate to the big houses, concrete houses, owned by the rich people. Near the Cagsawa ruins. It is owned by engineer – so they are rich – they are concrete houses. The poor people evacuated there but the Mayon lahar destroyed all the houses so all of them are affected.'* (DRR Point Person, Local NGO A)

The above quotation also highlights that the event affected both the rich and the poor:

> *'Even if you are rich or poor for as long as you are located in the proximity of that impact then you are not safe.'* (LG Disaster Manager 2)

This is an interesting point since there was a tendency amongst some NGO Head Office interviewees in Chapter 4 to assume the poorest are the most vulnerable. The occurrence of secondary hazards highlights a need to challenge this underlying assumption. The immediate impact of a multi-hazard disaster – particularly one of this magnitude – may affect everyone within a community.

[14] For example, Gemma moved to Maria's concrete house (Tandarora). Interviewees in Binitayan said the lighter material homes were destroyed. Irma and Antonio (San Antonio) stayed in their concrete home because they perceived to be safe and said that 15 residents joined them (home was flooded and lost roof, also affected by lahar).

Figure 7.7 Gemma's home in Tandarora, which is made of indigenous materials. It was damaged during Milenyo and completely destroyed by lahars during Reming (October 2012). Source: author's own.

Figure 7.8 Jerry's home in San Isidro, which is made of indigenous and improvised materials. It was completely destroyed by lahars during Reming (October 2012). Source: author's own.

Figure 7.9 The ruins of a concrete home in Tandarora destroyed by lahars during Reming (October 2012). Source: author's own

Across the barangays, those residing in homes constructed form light-weight materials described them as being a 'wash out', in other words completely destroyed by the floods or lahars:

> *The flood was very strong. There was lahar. House was totally washout* [destroyed]. (Edraline, Barangay Lidong)[15]

Not all of those residing in concrete homes described them as being completely destroyed – a resident of Tandarora said that only the kitchen at the back of her concrete home was devastated. However, the intensity of the typhoon was so great that even concrete homes were not impervious to its wrath. In Salvacion, (situated beyond the danger of lahars: see Figure 6.6) resident Myrna said that the roof of her concrete home blew off during the event. In general, however, it was clear from field observations in the barangays visited that the lahars had devastated concrete structures as the remains of ruined structures were present, particularly in Tandarora and Binitayan.

[15] Translated by LG Disaster Manager 1

There were mitigation structures, for example earth and concrete dikes, but these were criticised in the literature for being designed and built in accordance with flood specifications and not major lahars (Paguican et al., 2009; see Fano et al., 2007). PHIVOLCS Geologist 3 stated that there was an apparent claim that the dike failure on the Masarawag Channel (see Figure 7.3) contributed to the size the lahar, but disputed this by arguing that it was too small to have made a significant difference to the size of the lahar. In general, however, six DRR stakeholders[16] either criticised or gave the impression that the dikes are not particularly effective owing to their design, location[17] or poor construction[18].

### 7.2.2 Timing and duration of the lahars

The typhoon hit the province early on the morning of the 30th November and the majority of residents interviewed recalled that it arrived around 8am (*cf.* Orense and Ikeda, 2007). The accounts regarding the timing of the lahars are, however, conflicting. Most writers place the first of three pulses of lahars occurring at 2pm (PHIVOLCS, 2006a and 2006b; Paguican et al., 2009); however, interviews with residents in Lidong, Tandarora and San Antonio suggest that lahars and flooding occurred during the morning (see Table 7.3). This finding is in agreement with the interviews conducted by Orense and Ikeda (2007), who state that witnesses observed 'heavy downpour, accompanied by [a] quick rise in floodwater and [that] the…lahar flow occurred during the period between 10am and 3pm' (2007: 1126). Some of the earlier times may reflect initial flooding, as volcanic debris flows often evolve from flood waters (Vallance, 2005). It is also important to be mindful of the accuracy of communities' accounts (see Guthrie et al., 2009), especially six years after the event.

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[16] International volcanologist: PHIVOLCS geologist 1 and 2; LG Disaster Manager 1 and 2; MGB regional geologist

[17] MGB Regional Geologist

[18] LG Disaster Manager 1

Paguican et al. (2009) suggest that the lahar-triggering rain started sometime between midnight on the 29th and 6am on the 30th November and ended between 6am and noon on the 30th November. They interpret the 2pm arrival of the 'massive dense flows' at 'all communities' as evidence that dikes must have been breached at this time because this was 'several hours after the first lahars were initiated' (Paguican et al., 2009: 855). However, according to PAGASA's records, the majority of the rainfall fell between 8am and 2pm on the 30th November (Figure 7.10), which better explains the timing of the lahars rather than a synchronous failure of dikes just before 2pm. Paguican et al. (2009) appear to have failed to adjust the Coordinated Universal Time (UTM) recorded rainfall to local time, whilst at the same time trying to compare these data to eye witness accounts of when the lahars occurred, which reflect local time. That being the case, they mistakenly describe the event as being 18 hours long, whereas community interviews and other studies indicate that the typhoon lasted for around nine hours (from 8am until 5pm on the 30th November; see also Orense and Ikeda, 2007; Table 7.3). Such an error has implications for misunderstanding the lag time between typhoon onset and lahar occurrence and the volume and intensity of the triggering rainfall, which forms the current means for issuing lahar evacuation orders at Mayon (see Chapter 8).

Table 7.3 Timings of Reming and the lahars as remembered by the lahar affected communities

| ***Barangay*** | ***Interviewee or group*** | ***Event start*** | ***Time of hazard occurrence*** | ***Description of hazard*** | ***Event end*** | ***Time of evacuation*** |
|---|---|---|---|---|---|---|
| ***Lidong*** | Women's group | 9am (already raining at 7am) | 10/11am | Flood/lahar | | 10am |
| | Renaldo | 9am | 10/11am | Lahars | | |
| | Edraline | 1am | 1pm | Lahars | | |
| ***Tandarora*** | Maria | 9 to 10am | 9 to 10am | Flooding and lahar | 1pm flooding stopped | 1pm |
| | Group (timing of the event mostly described by one female resident: Marilu) | 9am (winds) | 2pm hear bumps (Marilu evacuates to big house with 15 families) | | In afternoon rain subsides. | 9am winds start (Marilu transfers to bigger, stronger house) |
| ***Binitayan*** | Women's group | | 1pm | Described a 'heavy flash flood' but called it a lahar. | 8/9pm | 2pm |
| ***Anislag*** | Women's group | 10am | 11am/12pm flood? | Described as lahar | 5pm | |
| ***Sua*** | Perla | 10am | | | | |
| ***San Antonio*** | Irma and Antonio | 9am | 1-3pm (strongest occurrence) | Started heavy flooding | 3pm (flooding subsided) - about 3pm you can pass through. | |
| ***San Isidro*** | Jerry | 7am (already strong by 8am) | 9am | | | |

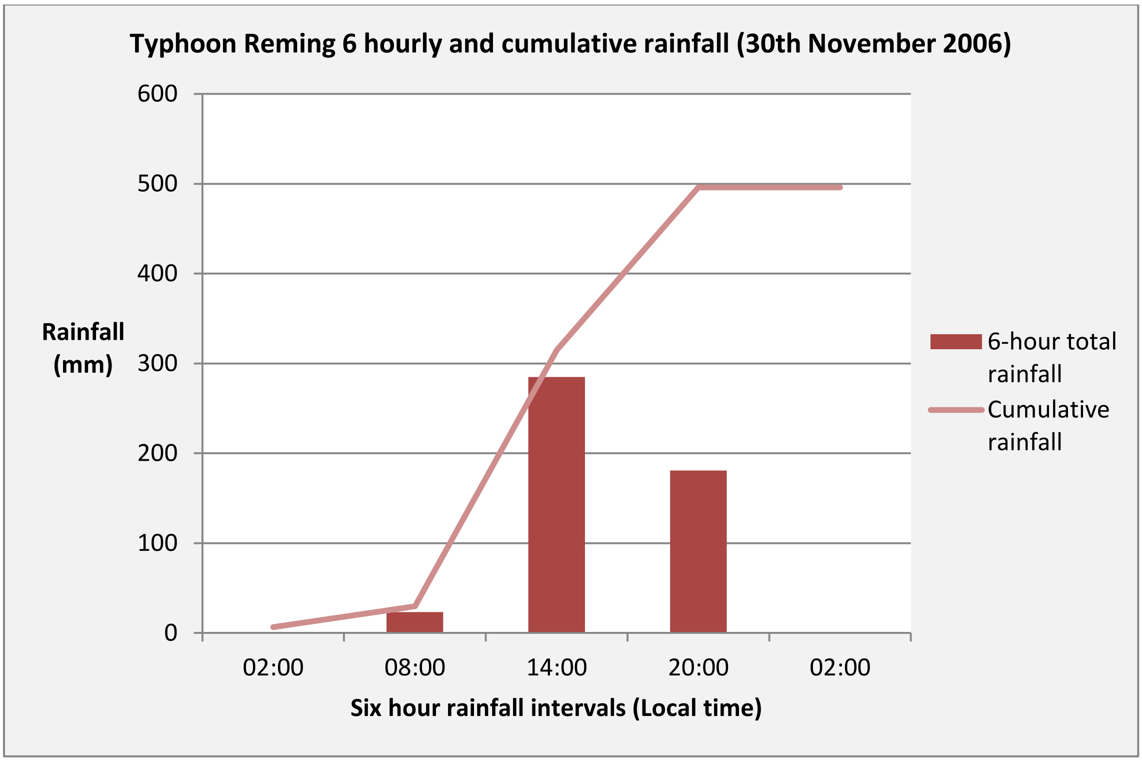


Figure 7.10 Accumulated rainfall during Typhoon Reming (from 2am on the 30th November to 2am on the 1st December 2006). The six hour recording intervals reflect the highest resolution of data available from PAGASA. Source of data: PAGASA (2012).

The timing and impact of the typhoon and lahars reflect the challenge of mitigating, preparing and warning for a multi-hazard disaster. Communities assumed they would be safe in their concrete homes from the impact of the typhoon; however, the compounding impact of the lahar meant that they were still vulnerable.

The timing of the lahar demonstrates the lag time between the onset of the typhoon and the occurrence of the lahar. It also demonstrates the importance of observations made by communities for the purpose of forensic analyses of disasters. Given the lag time between the typhoon onset and the lahar impact, along with the fact that the Philippines has a long-established institution for typhoon forecasting and rainfall monitoring (PAGASA), the following section explores the appropriateness of the warning and response to the disaster.

## 7.3 Warning for the multi-hazard disaster

Once the typhoon entered the Philippine Area of Responsibility (PAR), typhoon warnings would have been issued by PAGASA within the lead times given in Table 7.1. It was (and is) the responsibility of the provincial disaster office (APSEMO) to issue warnings to prepare or evacuate and these were disseminated through municipal disaster coordinators, who in turn informed Barangay Captains. The Barangay Captains were responsible for disseminating this information to their residents. Weather forecasts and warnings were also available online, through the television and via the radio, however the radio transmissions can be challenging for communities to understand[19]:

> *'Like we have a standard forecast from the weather bureau – you have meteorologist describing coordinates, this is the gustiness – this is the official advisory but would you really think this ordinary housewife would understand the coordinates of gustiness and this wind strength and how many kms would be the radius – these are technical that has to be translated to a language that would be understood by them and into actually indicators, or at least visible signs.'* (Executive Director, Local NGO B)

Local NGO A also recognised this challenge and, since Reming, has trained their communities to conduct typhoon tracking, by mapping the coordinates of the typhoon. In addition to this lack of understanding, as the following discussions shows, poor communication and inadequate lahar warning – brought about by confusion over the responsibility for monitoring and warning for the lahars – contributed to impact of the Reming disaster.

### 7.3.1 Single versus multi-hazard warning systems

Typhoon Reming first entered the Philippine Area of Responsibility (PAR) as a Tropical Storm on the morning of the 28th November 2006 (local time), 48 hours before it made landfall in Albay (Figure 7.11). The PAGASA warning bulletin issued at 11am on the 29th November contained a statement cautioning those residing in coastal regions of the threat of storm

[19] They just give the coordinates of the typhoon, rather than place names (Executive Director, Local NGO B)

surge and those in mountainous areas of the threat of landslides and flash floods, but did not make specific reference to lahars (see PAGASA, 2006). However, in general, it appears that the major problem with warning was that it was largely single event focused (i.e. for a typhoon) as well as single hazard focused (i.e. designed to reflect wind speed; Table 7.1).

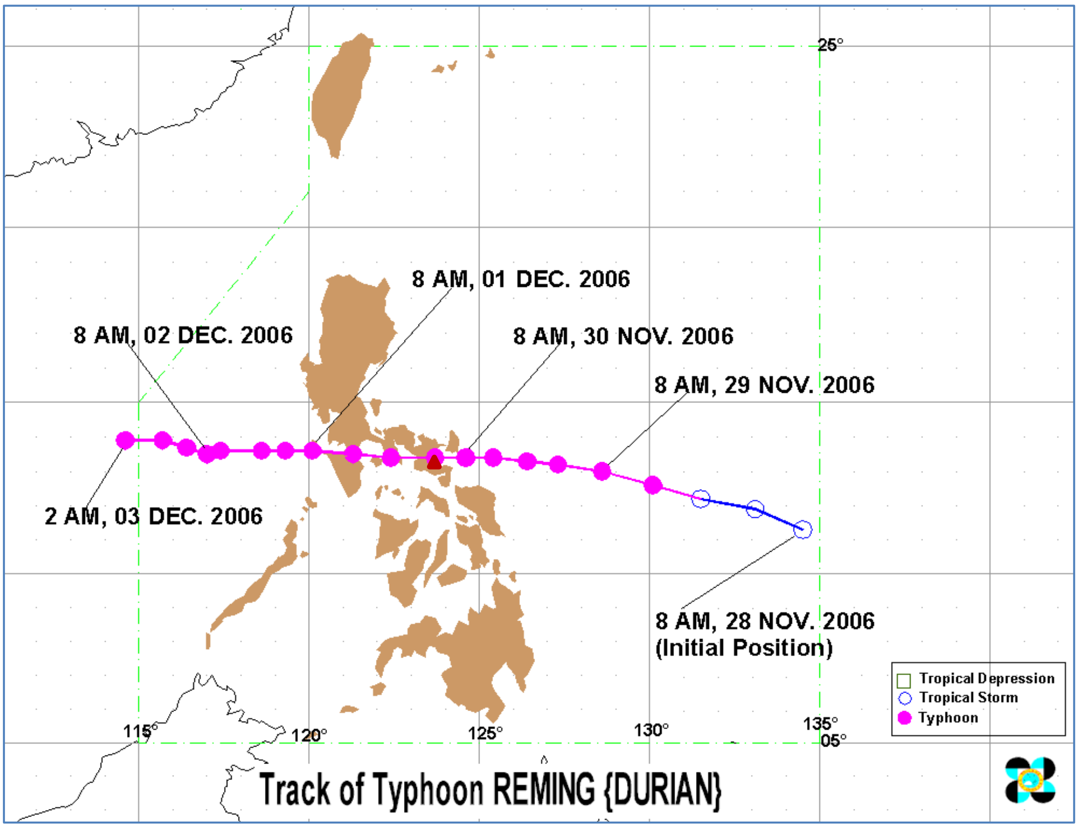


Figure 7.11 Track of Typhoon Reming produced by PAGASA. The location of Mayon is indicated by the red triangle and the PAR is delineated by the green dashed line. Source: PAGASA (2007).

In Chapter 4, one of the identified constraints on adopting a multi-hazard approach by NGOs is their silo approach to their work. What emerged during typhoon Reming is that these silos also relate to hazard scientists and can cause confusion regarding the monitoring and anticipation of secondary hazards. Whilst initiatives like the multi-hazard READY project (see Benson, 2009) have gone some way to bring about more synergistic working between government technical agencies, the lack of mutual understanding that emerged during Reming over whose responsibility it was to warn for lahars highlighted a shortfall. Academic Geologist 1 said that this was because lahar warning falls under the mandate of PHIVOLCS and not PAGASA and this interviewee suggested that it is uncommon for lahars to occur without an eruption and so PHIVOLCS was more used to volcanic lahars. PHIVOLCS Volcanologist 1 admitted that although there were pre-installed trip wires (sponsored by the Japan International Cooperation Agency, JICA) for lahar detection these were non-operational during Reming. This interviewee stated that, in the past, PHIVOLCS seismographs picked up lahars (e.g. the 1986 large lahars; see Okkerman et al., 1985), but this does not seem to have been incorporated into any sort of warning system.

In PHIVOLCS' defence, PHIVOLCS Geologist 3 felt that PAGASA had not provided sufficient updates about the rainfall and had adopted a 'business as usual approach':

> *'People were blaming us in some way* [but]…*The people who were manning the Legazpi station knew that a typhoon was coming but didn't make it a point to make much more frequent measurement of rainfall or they didn't make a point to make themselves more visible with information. They were, like many in the government bureaucracy, just doing routine work without really thinking how it would impact lives of the people – they were just doing the usual six hour periodic measurement of rainfall - this is for Legazpi station. Even the weather bureau here* [Manila] *didn't make it a point to issue bulletin much more* [often] *than every six hours'* (PHIVOLCS Geologist 3)

Thus, part of the problem then seems to have been a lack of sharing of information between the warning agencies. Whilst it was not possible to interview a PAGASA representative at the national level[20], an interview with a representative of the Bicol regional team indicates PAGASA's view that lahar warning is the responsibility of PHIVOLCS:

> *'Because we just give the rainfall but the amount of lahar that will flow is not in our agency; it is in Philippine volcanology – they are the one in charge.'* (PAGASA Regional Meteorologist)

[20] The personnel were too busy.

However, a number of changes have been made to the way PAGASA communicates information; updates have gone from six hourly to hourly and they now provide local weather reports on their website. Whether this is an acknowledgement of their accountability during Reming or at least recognition of the need for improvement can only be speculated.

In terms of key decision-makers, the local NGOs interviewed as well as LG Disaster Manager 2 criticised the typhoon warning for not including critical information; for example, Local NGO B programme staff representative felt that the message was confusing and the track of the typhoon was unclear. This interviewee also felt the warning lacked information about the volume of the lahar that could be triggered by the rainfall:

> *'Lahar was actually dislodged because of the rainfall. If they were able to predict the rainfall they would be able to predict the amount of mass that would be dislodged by that amount of rainfall so there was no prediction. There was a prediction at the bureau level but the communities were not informed.'* (Executive Director, Local NGO B)

This NGO representative perceived that the government scientists should be able to predict the magnitude of the lahar based upon the rainfall. Two other NGOs[21] and one local government[22] representative felt that the design of the warning message was a failure since it related more to the wind rather than the rainfall that would trigger the lahar:

> *'The people were focused on warning information from PAGASA about the signal number 1, 2, 3 that means the warning information is all about wind…and there is, even up to now, there is an information about the amount of rainfall but there's no information about warning on flood and landslide – it's general.'* (LG Disaster Manager 2)

Critical rainfall threshold triggers for lahars at Mayon were calculated in the 1980s (Rodolfo and Arguden, 1991) but these do not appear to have been utilised as a basis for warning by

[21] Both interviewees from Local NGO B
[22] LG Disaster Manager 2

local government during Reming[23]. Furthermore, it was not apparent that the NGOs interviewed were utilising community-based monitoring and warning based upon rainfall volumes, so it is unclear how NGOs and communities might have benefited from the sharing of this information. Further discussion of the role of rainfall thresholds as a means of anticipating multi-hazards is included in Chapter 8.

In spite of the above criticisms of the typhoon warning, three PHIVOLCS scientists[24] said that there was a warning issued for lahars and LG Disaster Manager 1 recalls giving barangay captains scenarios of what might occur given the typhoon warning, which included lahars. Similarly OCD Regional claims that the message contained warning for lahars; however, he was not in the province (nor in his current job) until the day after the typhoon struck, which questions the validity of this statement.

Moreover, in spite of LG Disaster Manager 2's criticism of the lack of rainfall information in the typhoon warning, they stated that they had anticipated lahars but that warning the people was challenging owing to the damage inflicted by Typhoon Milenyo two months earlier:

> *'…almost…half of the area of the province have no electricity during Reming because all the electrical poles were toppled down by Typhoon Milenyo so it was very hard on us to communicate to them…'* (LG Disaster Manager 3)

This situation emphasises that contingency planning and disaster preparedness have to be revised to reflect the impact of earlier hazards and disasters.

### 7.3.2 Community receipt of and response to the warning

During six community interviews[25], residents recalled seeing or hearing the forecast for the typhoon, for example on the television or over the radio, with three mentioning they received

[23] LG Disaster Manager 2 (email correspondence 7th March 2014)
[24] PHIVOLCS Geologist 1; PHIVOLCS Geologist 2; PHIVOLCS Volcanologist
[25] Maria, Group and Gemma (Barangay Tandarora); Groups in Barangays Anislag and Binitayan; Jerry (Barangay San Isidro)

the warning the night before[26]. These warnings do not appear to have contained information about the lahar:

> *'…news about the typhoon, but the lahar was a surprise for us.'* (Gemma, Barangay Tandarora)

The preparations the residents made suggest that they were concerned with the wind rather than the lahar hazard:

> *'*[We] *cutted the leaves of the plants so it will not be affected by the wind so that's the one* [we] *prepared.'* Maria (Barangay Tandarora)[27]

It therefore appears that residents were not anticipating the secondary events that a typhoon could trigger, or at least not the potential severity of these events.

Residents from Salvacion and the women's group in Lidong recalled receiving a typhoon warning from the barangay officials, whereas other interviewees in barangays Lidong[28], Tandarora, Binitayan, Anislag, Sua and San Isidro did not receive any warning to take action against a typhoon or lahar.

In spite of the PAGASA typhoon warning being issued at least two days in advance of it arriving in Albay, a member of the Disaster Preparedness Committee for Barangay Sua said that they did not have time to warn their community of the incoming typhoon during the morning of the 30th November:

> *'No more time for the warning signals - we were caught unaware by the incident.'* (Perla, Barangay Sua)

[26] Merlihma in Barangay Salvacion (almost a day); women's group in Barangay Lidong (received it 12 hours beforehand, but were resistant to evacuate but then copied others); Maria in Barangay Tandarora - Maria (over the radio; no message about lahar), Group (warning on the evening of the 29th, no information about 'Mayon activities')
[27] Translated by Local NGO B programme staff representative.
[28] Apart from the women's group.

The above quotation highlights a lack of anticipation of the event, demonstrating that even barangays with DRR training were ineffective during the event. Four community interviewees[29] attributed part of the problem to the last minute shift in the track of the typhoon. Whilst this shift does not relate specifically to multi-hazards, it is important to explore since it changed people's perceptions of their risk and indicated a limited understanding and/or poor communication of scientific uncertainty. The change in track of the typhoon was mentioned during three group interviews (in Binitayan, Tandarora and Anislag), two of which (Binitayan and Anislag), along with Jerry from Barangay San Isidro, specifically made mention to the fact that Reming was forecast to hit Catanduanes. Catanduanes is approximately 60km north of Albay and the northward tracking path is confirmed by the warning issued by the Joint Typhoon Warning Center on the 29th November (Figure 7.12). In anticipation of the typhoon path, PAGASA deployed staff in Camarines Norte because it was 'predicted to be along the path of Typhoon Reming' (PAGASA, 2007: 2). Catanduanes was still inundated with rain (see Figure 7.13) and even if the typhoon had tracked 60km north it may have still brought enough rainfall to trigger the lahars at Mayon. However, PHIVOLCS Volcanologist 1 pointed out that it was the passing of the typhoon eyewall close to Mayon that brought the heavy rainfall required to trigger lahars.

Whilst this last minute shift was unexpected, the fact that communities seemed to take solace in the fact that the typhoon was tracking towards Catanduanes implies a limited understanding or poor communication of the associated uncertainty with any warning:

> *Science based warnings have a lot of uncertainty – difficult to be understood by the lay person. In order to understand the uncertainty, need someone to be good at communication.* (Academic Geologist 1)

Figure 7.12 shows the predicted typhoon path, including the uncertainty regarding the forecast typhoon track, which is indicated by the shaded area. The explanation of this shaded area is

[29] The group interviews in Binitayan, Tandarora and Anislag; interview with Jerry (Barangay San Isidro)

notably absent. The original PAGASA bulletin tracking map is not available so a comparison of the communication of uncertainty could not be made.

Residents taking solace in the fact that the typhoon was tracking further north was a reflection of the reliance on previous experiences:

> *We are basing our experiences that, if the typhoon will hit the Virac* [in Catanduanes] *we'll not be affected.'* (Rosemarie, Barangay Anislag)

However, a report by the PAGASA STRIDE team states that the typhoon made landfall just south of Virac (PAGASA, 2007). Therefore, whilst the experiences of the interviewee above may have assisted her the past, it is implied that these were based on the occurrence of smaller or less intense typhoons hitting Virac. These past experiences therefore did not account for the possibility of a typhoon as powerful as Reming. Interestingly, four DRR stakeholders[30] mentioned the shift in the typhoon direction, but they did not mention any significance of this change in terms of the preparations adopted prior to the typhoon[31]. This indicates a failure in the communication of the threat posed by the typhoon to communities. Communication is only effective if it is understandable and it is apparent that some communities did not understand the threat posed by Typhoon Reming.

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[30] OCD Regional; Academic Geologist 1; PHIVOLCS Geologist 3; (MGB Regional Geologist said that it was going to pass close to the boundary between Camarines Sur(Sipocot) and Camarines Norte)

[31] Except for MGB Regional Geologist who said it caught her unaware (she is not part of a responding agency)

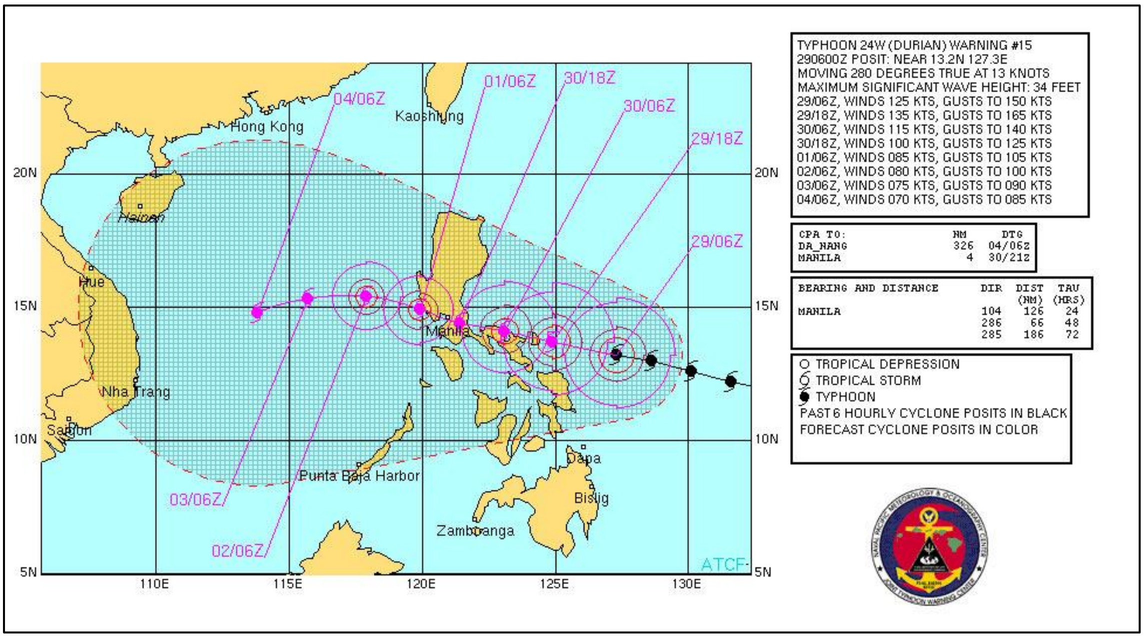


Figure 7.12 Typhoon warning at 6am UTC (2pm local time) on the 29th November 2006. The past six hourly cyclone positions are in black and the forecast cyclone positions are in pink. Source: NASA (2006)

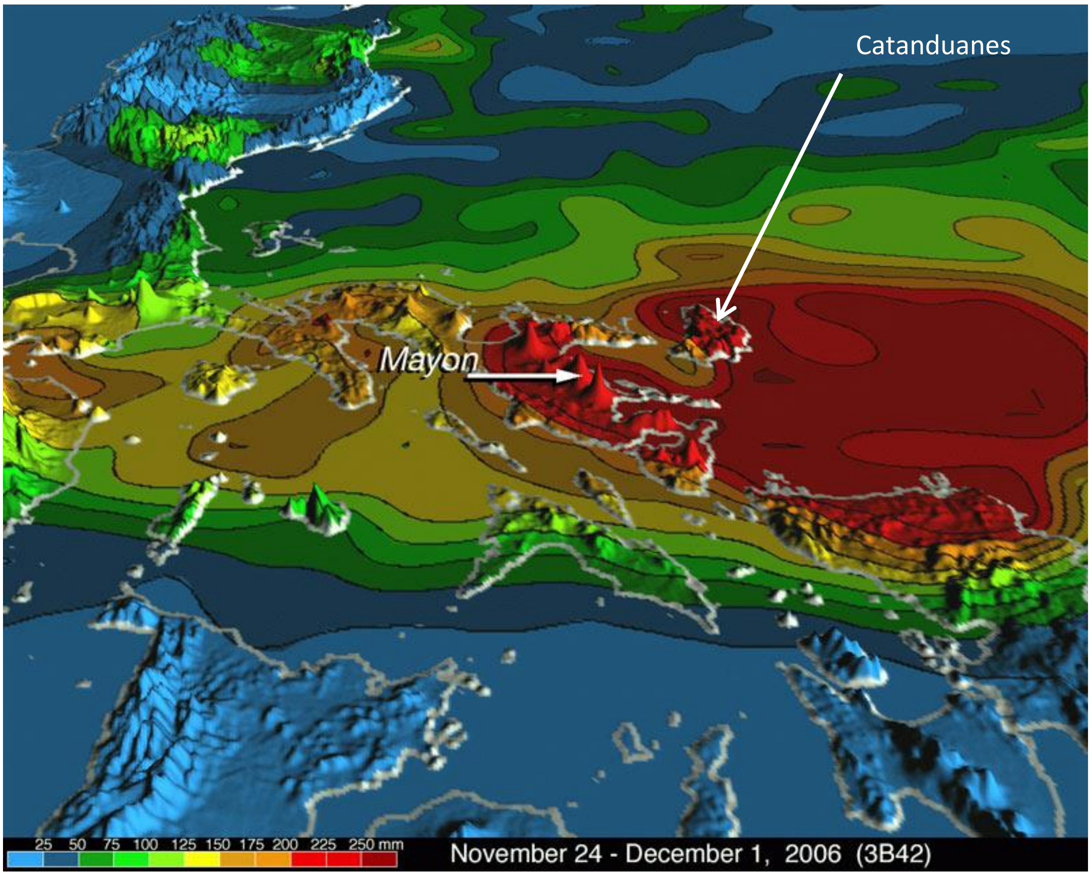


Figure 7.13 Tropical Rainfall Measuring Mission (TRMM) radar imaging of rainfall totals for the period between 24/11/06 and 01/12/2006. Source: adapted from NASA (2006).

The majority of the communities interviewed described the typhoon as occurring very suddenly, reflecting the last minute shift in the typhoon as well as the lack of official warning. Part of the problem came down to the failure of the centralised communication system; the earlier damage by Typhoon Milenyo meant that once Reming began it was difficult to tell communities to evacuate because of damaged power lines. The Executive Director of Local NGO B suggested establishing greater awareness amongst communities in case of similar failures in communication, whilst the other representative of NGO Local B said there is a need to strengthen the autonomy and capacity of local communities to monitor and warn for local disasters:

> *'…at the barangay there's also a local disaster – the APSEMO doesn't know – so you must teach community how to detect that certain hazard or disaster. Not rely only to the information coming from APSEMO.'* (Programme staff representative, Local NGO B)

This need is apparently recognised by several authors who, after Reming, made recommendations to strengthen community-based warning systems (e.g. PHIVOLCS, 2006a; Orense and Ikeda, 2007).

### 7.3.3 Decision to evacuate

In spite of the above criticisms of the warning system, five DRR stakeholders (scientists and local government) [32] said that some residents chose not to evacuate despite being warned (*cf.* Paguican et al., 2009). However, given the DRR stakeholders felt that the risk of lahars had not been properly conveyed to them, it is questionable whether the true threat of the typhoon was fully communicated to, or understood by, residents:

> *'…*[we didn't] *really expect that Reming would be that great, why? Because* [we] *were thinking that it would just be rains, rains and rains similar to the previous day.'* (Irma and Antonio, Barangay San Antonio)

[32] LG Disaster Manager 1 and 2; International Scientist; PHIVOLCS Geologist 1; PAGASA Regional Meteorologist

Of the residents interviewed, a few moved to neighbours' homes before the typhoon[33], but the majority appear not to have attempted evacuation until after the onslaught of the typhoon[34], but by then many were not able to owing to the intensity of the typhoon[35].

Residents' decision not to evacuate was attributed by some DRR stakeholders as being due to communities' recent experience of Milenyo[36] (as observed by Orense and Ikeda, 2007):

> *'One of the things that we heard over and over again was people, even though they were warned about Reming, they were warned to get out of the way, many people did not and what they said was: "well we got warned during typhoon Milenyo too and nothing happened, we were okay, so we just assumed that it would be the same."'* (International Volcanologist)

Milenyo (and perhaps previous typhoons) had arguably created a 'normalisation bias' (Johnston et al., 1999) which is when residents perceive their recent experiences of disasters to be indicative of the future, resulting in their being less attentive to hazard information and less responsive to warnings. During interviews with communities, it was difficult to determine whether this normalisation bias was truly present[37], but given community interviewees' relatively passive reaction to the typhoon warning, the lack of enhancement of their regular preparedness measures and the fact that many made comments comparing Reming to previous experiences[38] it is a plausible suggestion:

> *'We stayed here* [unclear]. *Because we know that it's only a regular typhoon, typhoon is - we used to it.'* (Maria, Barangay Tandarora)

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[33] Gemma (Barangay Tandarora)
[34] For example, Myrna (Barangay Salvacion); Leja, women's group and Edraline (Barangay Lidong); Maria (Barangay Tandarora); women's group (Barangay Anislag)
[35] For example Perla (Barangay Sua)
[36] International Volcanologist; PHIVOLCS Geologist 1 and 2; LG Disaster Manager 2; Local Health Volunteer
[37] Myrna (Barangay Salvacion) stated that Milenyo did not make her complacent, but she was not affected by lahar
[38] Rosemarie (Barangay Anislag); Irma and Antonio (Barangay San Antonio)

Given the trauma communities endured during Reming[39], as well as the heightened awareness they now appear to have, it was likely difficult for communities to reflect on whether they had been complacent prior to Reming or not. Nevertheless, the concept of normalisation bias has highlighted the need to include the social influences of previous hazards within vulnerability frameworks looking to address multi-hazard risk. This example also reemphasises the limits of community knowledge in terms of anticipating hazards.

PHIVOLCS Volcanologist 1 felt that Milenyo had more of an impact in terms of communities' ability to evacuate rather than any influence on their perception of risk. This interviewee stated that communities' awareness of the risk was reasonably high but that because the *'strong typhoon* [Milenyo] *prior to Reming'* had destroyed evacuation centres people chose to stay at home, where they felt safer (see also Usamah and Haynes, 2012), although this interviewee tended to defend PHIVOLCS' position and actions and those of the residents of Albay when answering questions[40]. Three DRR stakeholders attributed the reluctance to evacuate to more generic factors, including the fear of losing possessions and due to poor conditions in the evacuation centre[41].

Residents' perceptions of risk had also been shaped by the many other typhoons and disasters they have experienced. According to one interviewee[42], residents chose not to evacuate because they assumed they could wait until they saw lahars and make the decision then. This observation indicates that they perceived the lahar to be very much like the recent 2006 lava flow (see Orense and Ikeda, 2007) and perhaps, having been evacuated during that event, they felt safe enough not to evacuate again.

[39] E.g. Women's group in Barangay Binitayan
[40] This stance probably reflects their key role in restoring faith in PHIVOLCS amongst local residents after they were blamed for the deaths of 77 people during the 1993 eruption.
[41] PAGASA STRIDE Team Leader; Deputy Executive Director (National NGO); LG Disaster Manager 3
[42] LG Disaster Manager 2

The criticism of the typhoon and lahar warning reflects (1) the institutional gap in monitoring and warning for secondary hazards (in this case lahars that occur without an volcanic eruption) and (2) the lack of communication between scientists, local government, NGOs and communities. Communities generally felt that they did not receive a warning, the decision-makers (NGOs and local government) felt that the critical information had not been shared and the scientists appear to defend their own actions and blame each other. In the aftermath of the disaster it is easy to say that lahars were expected and to criticise others for the lack of detailed information that could have improved preparing for this event (*cf.* Tweed and Walker, 2011). However, it is apparent that scientists, local government, NGOs and communities alike were surprised by this event, particularly in terms of the magnitude of the lahars, emphasising a general lack of anticipation of this secondary hazard.

## 7.4 Anticipating lahars: an unexpected occurrence of a common hazard

In spite of an ongoing programme of hazard mapping at Mayon volcano by PHIVOLCS, the previous discussion implies that the disaster caught DRR stakeholders and communities by surprise. The following discussion explores the hazard assessments – both scientific and community-based – conducted prior to the disaster, along with changes in the environment (e.g. channel migration) that retrospectively indicated increased lahar risk to communities.

### 7.4.1 Scientific lahar hazard assessment

At the time Reming occurred (November 2006) the most up to date lahar hazard map was that produced by PHIVOLCS in 2000 (Figure 7.14). It depicted three classes of lahar hazard: areas least, moderately and highly prone to lahars, which were distributed around the volcano, with the highly prone areas concentrated in gullies.

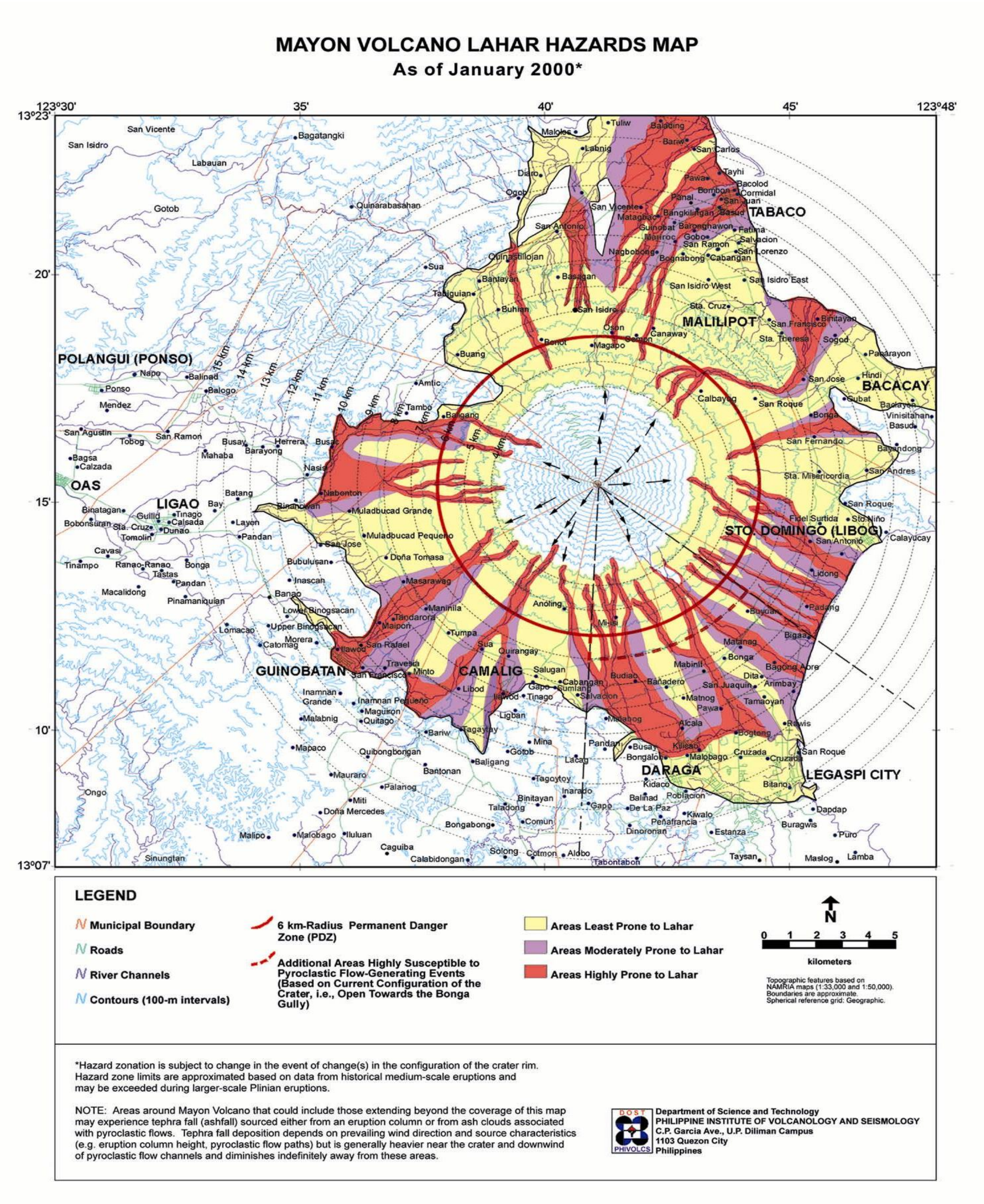


Figure 7.14 The 2000 lahar hazard map for Mayon volcano. Source: PHIVOLCS (2000).

The map included no information as how to interpret these classes and, as a consequence, the hazard classes are slightly ambiguous, but the implication is that highly prone areas are frequently affected by lahars of any size, whereas those areas least prone will only be affected during large events. This has important consequences since it was the magnitude of the Reming lahars that particularly surprised residents and stakeholders. The implications of trying to map a dynamic hazard like lahar are explored in greater detail in Chapter 8.

PHIVOLCS printed the lahar map before Reming and had communicated this to (at least) local government through Information Education Campaigns (IECs)[43]. LG Disaster Manager 1 queried, however, whether the map would have actually reached the barangay residents:

> *'The barangay officials knew the area but I doubt whether those maps were really disseminated previously to the barangay folks and what we are now doing is to make those maps smaller maps and give it to the villagers'* (LG Disaster Manager 1)

PHIVOLCS interviewees generally felt that the map had anticipated almost every area inundated by the Reming lahar[44], with an acknowledgement that the lahars extended further downstream in Guinobatan and Daraga than what might have been expected:

> *'In Daraga it essentially eroded some more – just a few metres of offset or excess to the lahar hazard map. Essentially people know those are areas that are threatened. It is just a matter of building in an area that is hazard prone.'* (PHIVOLCS geologist 1)

Interviewees in Binitayan and Anislag (in Daraga) were, however, very much surprised by the impact of lahars in their barangays:

> '*It* [lahar] *is only Reming.'* (Women interviewed in Barangay Binitayan)

Regardless of whether or not communities had seen the PHIVOLCS hazard map[45], it was generally perceived amongst the DRR stakeholders that the awareness levels of Mayon residents were relatively high, owing to their vast experience with hazards and disasters[46]:

[43] International Volcanologist
[44] Also corroborated by OCD Regional 1

> *…Yes,* [lahar] *has certainly happened previously. Always expect lahars after rainfall but* [we] *are praying for no more.* (Leja, Barangay Lidong)

At the same time, concern over preserving communities' memories of this event and previous disasters particularly emerged during the interviews with scientists[47], but was also noted by other DRR stakeholders[48]:

> *'Even with a volcano that is regularly erupting and with people experiencing very frequent lahars and floods this Reming event was significantly devastating because people tend to forget or did not have it in their experience in their lifetime that lahars occurred in their place.'* (PHIVOLCS Geologist 1)

As such, communities were not anticipating the occurrence of devastating lahars, which suggests that their prior experience of lahar was insufficient for them to anticipate this disaster.

### 7.4.2 Community based hazard mapping and prior experiences of the lahars

Eight interviewees[49] across five of the barangays described past experiences of lahars, whereas four others (including three groups) had no prior experience of lahars[50]. Communities further up slope described these experiences in the context of historical eruptions and heavy rains[51] and two residents in Barangay San Antonio remembered lahars occurring during Typhoon Sisang (1987). Nevertheless, there was a general sense that:

> *'the Reming lahars really did, as far as people were concerned, come out of the blue'* (International Volcanologist)

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[45] PHIVOLCS Volcanologist 1

[46] Deputy Executive Director (National NGO); MGB Regional Geologist; PHIVOLCS volcanologist; Executive Director (Local NGO B)

[47] PHIVOLCS Geologist 1; International Volcanologist

[48] Deputy Executive Director (National NGO) (communities experienced this kind of activity 20 years ago but their memory of it has faded)

[49] Barangay Lidong: Leja, Renaldo and Mercedes; Barangay Tandarora: Maria (but not boulders), group (eruption lahars), Gemma (Milenyo lahar); Barangay Sua: Perla (during eruptions): Barangay San Antonio: Irma and Antonio (Sisang); Barangay San Isidro: Jerry

[50] Barangay Lidong: women's group and Mercedes; Barangays Anislag and Binitayan

[51] Barangays Tandarora and Sua

Interviewees in Lidong, Tandarora, Anislag, Binitayan and San Antonio expressed that the occurrence of this event, in particular the lahar, was unexpected:

> '[Lahar was] *first time in history'* (Lolita, Barangay Anislag)

According to PHIVOLCS (2007a), in comparison to those residing alongside other active lahar channels in Mayon, communities along the Masarawag Channel (Figure 7.3) had no recollection of even the smallest lahars affecting their communities prior to Reming. However, in Barangay Tandarora (located near the Masarawag) the group interviewed mentioned lahars during the 2000-2001 eruptions and Gemma said that she'd been affected by lahars, which she described as 'flooding', during Typhoon Milenyo, but that she was still surprised by the Reming lahars.

Of the seven barangays visited during the field work, only the residents of Barangays Tandarora and Sua had been involved in community-based participatory mapping and disaster preparedness, and had established an early warning system. These activities had come about through their partnership with Local NGO B with whom they had been working to address flood risk on Mayon volcano:

> *'even if there is no typhoon, there is no like eruption, only with like a significant amount of rainfall these communities get flooded. So actually the project* [we] *initiated in 2004 was a flood preparedness project in response to big floods that happened.'* (Executive Director, Local NGO B)

As the above quotation highlights, flooding and lahar are almost discussed interchangeably, but these hazards can have very different impacts, as was demonstrated during Typhoon Reming. The results of the community-based assessment of risk also indicate how risk perception leads the process, with the communities most concerned with addressing the hazard they had recently and frequently experienced (noted in Chapters 4 and 5). In 2006 (prior to Reming), the National NGO partner of Local NGO B conducted a review of their community-based risk assessments at Mayon, within which they made reference to the hazard mapping conducted by PHIVOLCS and recognised the communities risk to lahar, ash and lava flow. But, Local NGO B programme staff representative emphasised that the community mapping process relies on information provided by the community:

> *'Actually in the barangay level they are the one who knows about their surroundings, with their experience of course.'* (Programme staff representative, Local NGO B)

The Executive Director of Local NGO B placed emphasis on the process of mapping rather than its accuracy, whereas the Deputy Executive Director of the National NGO felt that the lack of scientific interpretation meant that communities were unaware of the risk from large lahars:

> *'During that time, that's the weakness part because it's, most of the mapping or the identification of hazards being done by the community. This is the problem they did not consult or get opinion from MGB then or the PHIVOLCS regarding the amount or how many boulders or lahar being in the mountains.'* (Deputy Executive Director, National NGO)

In spite of the emphasis on community knowledge, the last interviewee stated that the community did identify lahar as a hazard, whereas the interviewees from Local NGO B stated that communities identified the volcano and the channels as sources of flooding, but that they did not *'single out lahar'*:

> '[they identify] *the rivers, because that's where the flood waters, lahars. But to single out lahar – I don't know; no, I don't think so. Volcanic eruption – when you ask them the hazard they will say volcanic eruption, which sometimes they confuse with Mayon volcano – they will say Mayon volcano.'* (Executive Director, Local NGO B)

Indeed, the faded 2004 hazard map created by residents in Barangay Sua makes reference only to 'eruption' and 'flood' hazard – although arguably lahar could fall into either of these given the spectrum of lahar hazards, from hyperconcentrated flow to debris flow, and its occurrence in syn- and post-eruptive settings. This is reflected by the fact that communities described the Reming lahars in terms of flooding and material coming from the volcano (see Section 6.5). But, as pointed out by the Deputy Executive Director (National NGO), the lahars that were triggered by Reming did not represent what the community understood as possible from their own analysis of risk:

> *'For what I know the concept of landslide to them is far from the landslide that had happened. They know that there will be landslide because it is a usual activity - landslide, flashflood…But in terms of imagining or giving, identifying the picture of...how many volumes or how many land or soil or lahar already there – that is the weakness that they could not really picture it...'* (Deputy Executive Director, National NGO)

The last quotation emphasises a weakness in community based hazard assessments that place too much emphasis on previous experiences of hazards and not upon anticipating the different potential magnitudes of those hazards.

As a response to Reming, the Barangay Sua hazard map in Figure 7.15 has been updated, but it was being stored in another barangay during the visit so it was not possible to observe the updates. In response to a prompt from Executive Director (Local NGO B), residents of Tandarora and Sua said they were more able to cope during Reming owing to the hazard mapping and training they had received through their partnership with Local NGO B. However, in Barangay Sua the Barangay Preparedness Committee did not issue a timely warning and this barangay and Barangay Tandarora were badly affected by lahar.

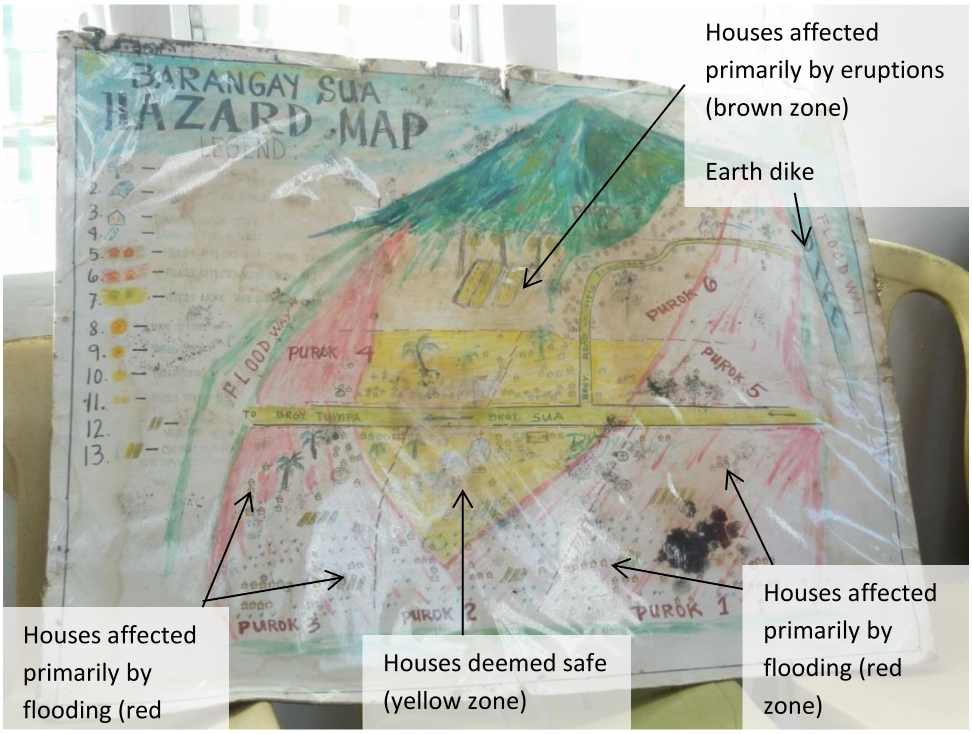


Figure 7.15 Community hazard map for Barangay Sua prepared in 2004. Owing to the faded legend, the photograph has been labelled to provide clarity. Note the earth dike in the top right corner of the illustration was intended to protect the community from flooding, but was destroyed during Typhoon Reming. Source: author's own.

### 7.4.3 Enhanced risk and missed warning signs: previous clues from Typhoon Milenyo

Two community interviewees in Barangays Tandarora and Lidong reported experiencing lahars during Milenyo, perceived to have been quite minor events, probably more reminiscent of sediment-rich floods rather than debris flows. PHIVOLCS Geologist 3 also mentioned the occurrence of small channel confined lahars in Barangay Padang during Milenyo. During post-event analysis of the devastation caused by Reming lahars in Padang, it transpired that the Milenyo lahars were actually an indicator of increased risk to Padang. These lahars were described as 'the only sizeable lahars experienced in the Padang-Buyuan area after the 2000-2001 eruptions and prior to Reming' (PHIVOLCS, 2007a: 2). The reason for the increased risk was postulated to be due to a small 'bypass' channel that developed 2km upstream of the confluence between Buyuan and Padang somewhere between May and July 2004 (PHIVOLCS, 2007a and 2007b; Figure 7.16). Interviews conducted by PHIVOLCS with several residents of Padang and upstream Buyuan confirmed that lahars shifted towards the Padang Channel during Typhoon Milenyo, resulting in stream abandonment of the lower Buyuan Channel (PHIVOLCS, 2007a). This 'stream piracy' increased susceptibility to lahar in the Padang Channel and resulted in Barangay Padang being worse affected during Reming compared to neighbouring barangays:

> *'this* [hazard] *was anticipated by the hazard map but in personal experience of people we didn't really anticipate that this* [Padang] *would be much more dangerous area than this one. There were a lot of people who died here.'* (PHIVOLCS Geologist 3)

Localised changes like this emphasise the dynamic nature of the Mayon edifice, which makes mapping lahar hazard in the short to medium-term challenging. This situation highlights the need for a localised approach to anticipating hazard exposure of communities through incorporating community observations of change. The example from Padang illustrates that, with the correct interpretation, communities' observations of the lahars during Typhoon Milenyo could have informed scientists of the increased threat well in advance of the Reming disaster. This also demonstrates the means of integrating community knowledge and scientific expertise via the respective provision of information (by the community) and interpretation (from the scientists), which was described by NGO interviewees in Chapter 5. In addition, the case of Padang also emphasises the need for communities to be aware of upstream environmental change that may affect them.

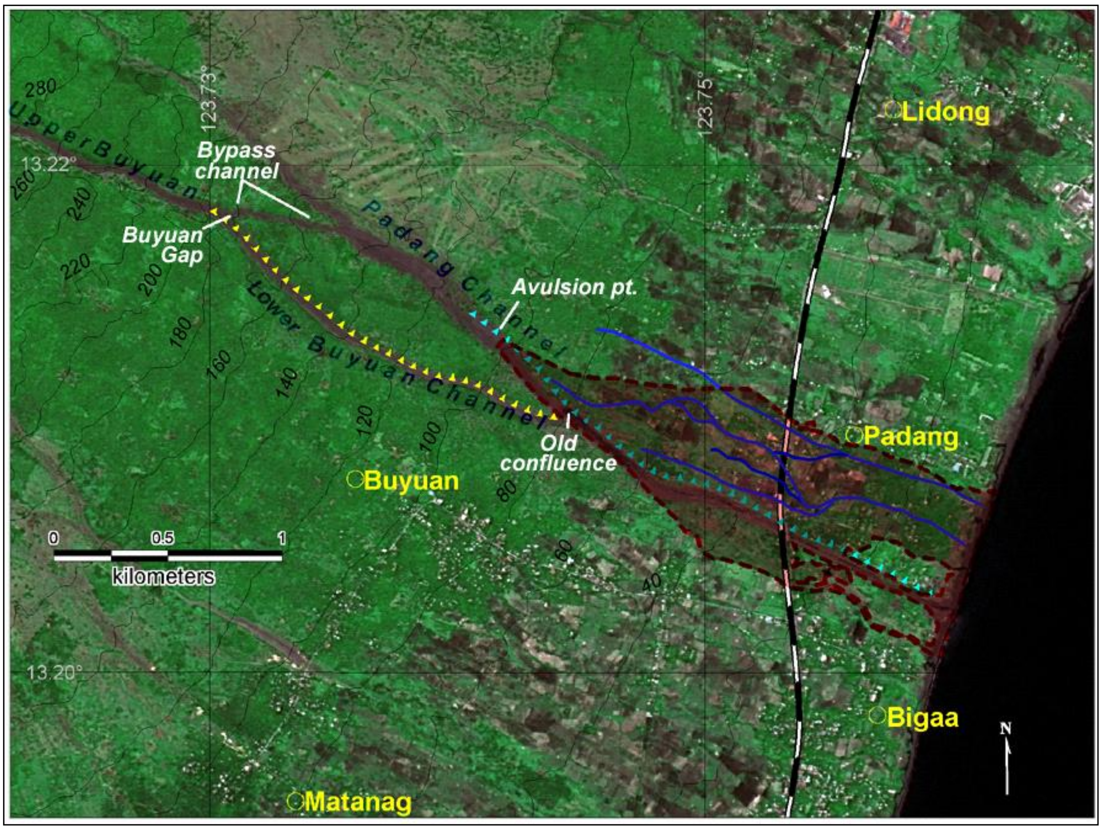


Figure 7.16 Pre-Reming (2005) SPOT5 imagery of Padang-Buyuan fan, super-imposed with the distribution map of the *Reming* lahar deposits and present-day features. Note that the bypass channel between the upper Buyuan and Padang Channels is already developed in this 2005 image. Active braided streamflow marking the new course of the lower Padang Channel runs through the centre of the deposit fan. Rechanneling of active flow into the old course of the lower Padang Channel is marked by the sand dike (light blue triangles). The map displays contours in metres. Source of map and caption: (PHIVOLCS, 2007a, fig 1: 2).

### 7.4.4 The unexpected magnitude of lahars

The DRR stakeholders, in particular the scientists, stated that it was not so much the occurrence[52] of the lahars that was a surprise but the volume and intensity of the event. Indeed the majority of DRR stakeholders and communities agreed that the magnitude of the disaster was particularly surprising[53], in particular that of the lahar:

[52] International volcanologist; PHIVOLCS Volcanologist 1 recalled typhoon triggered lahars in the mid-1980s

[53] PHIVOLCS Geologist 1 and 3; PHIVOLCS Volcanologist 1; MGB Regional Geologist; International Volcanologist (surprise where it exceeded channel capacity); Executive Director and programme staff representative (Local NGO B); Deputy Executive Director (National NGO) (said that the local government unit were not aware that the magnitude was a surprise); DRR Point Person (Local NGO A); PAGASA

> '[local government] *would normally say in his presentations that the province was prepared, APSEMO was prepared, but the level of preparedness was not enough. The magnitude…was unexpected'* (Executive Director, Local NGO B)

The DRR Point Person from Local NGO A said that the government had undertaken worst-case scenario planning but that this had not anticipated an event as large as Reming. This lack of anticipation is emphasised by the fact that, according to the MGB Regional Geologist, the local government was focused on evacuating people from coastal regions due to the risk from a storm surge, rather than evacuating residents from the slopes of the volcano. This interviewee thought that the local government were probably expecting lahars, but not of such magnitude. Thus, the local governments' response was shaped – similar to those of communities – by their experience of previous disasters and their perception of risk. Furthermore, the resources of the local government were already stretched because they were still dealing with the aftermath of Typhoon Milenyo[54]. The situation demonstrates not only a lack of anticipation but also a need for community-based DRR that is not fully reliant upon support from the government.

This lack of anticipation shows an underestimation of the potential for large typhoon-triggered lahars and questions whether the underlying science behind the scenario planning was of utility:

> *PHIVOLCS were more used to eruption lahars.* [They] *realised they needed more studies to look at similar events…There were clearly pyroclastics on top but these had become vegetat*[ed] *and so the assumption was that they had already stabilised. Nobody had really looked into this event happening* (Academic Geologist 1)

The lahar hazard map had identified the majority of the areas affected by lahar, but it had been five years since the last eruption so it is questionable whether any DRR stakeholder was truly anticipating the occurrence of an event of this size. There appeared acknowledgement

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Regional Meteorologist and Academic Geologist 2 (amount of rainfall unexpected); LG Disaster Manager 2 (did not expect lahar would reach certain places)

[54] LG Disaster Manager 3

that Albay was prepared but that the event was beyond what they could cope with, which appeared designed around a worst-case scenario which had underestimated the magnitude of this type of event (*cf.* Tweed and Walker, 2011). This is also in spite of the fact that there have been large post-eruption lahars in the past, for example the 1875 lahars that killed 1500 people (Ramos-Villarta et al., 1985).

The lack of anticipation of this event also emphasises a weakness within NGO PHVCAs that focus upon what communities have experienced in the short-term. The community based hazard assessments therefore need to take account of whether known hazards (such as lahar) might manifest as greater magnitudes or occur under different circumstances (e.g. during a large typhoon rather than an eruption):

> *'Before the Reming, we did not anticipate that there would be a Reming.'* (Deputy Executive Director, National NGO)

However, in the context of integrating science, the scientists do not appear to have anticipated the magnitude of this event and the hazard map requires user interpretation to determine those areas that might be affected by large lahars.

The discussions so far have highlighted many unexpected elements of the Typhoon Reming disaster: the shift in the typhoon track, the localised changes in some channels, the intensity of the rainfall and – for some – the occurrence of the lahar. However, as previously stated, what appears to have been resoundingly unanticipated was the magnitude of the lahars. This indicates a limit to both the community and scientific knowledge for the purposes of anticipating multi-hazard disasters. Part of the problem, amongst the communities especially, is a lack of understanding of lahar occurrence in post-eruption settings.

## 7.5 Understanding the cause of the lahars: comparing scientific and community knowledge

Chapters 4 and 5 explored the relative importance of community and scientific knowledge in NGO community-based risk assessments. As has already been outlined in the present chapter, the Reming lahar disaster was not particularly well anticipated by either communities or scientists and the communities had no living memory of such an event occurring. The understanding as to why Reming triggered lahars is, therefore, discussed below.

### 7.5.1 Communities' understanding

The accounts of residents affected by the lahar enabled scientists to interpret what had happened (e.g. Mirabueno et al., 2006; Orense and Ikeda, 2007), particularly because *'so much that actually mattered to the Reming event*[55] *was lost in the urgency of the first month after the disaster'* (PHIVOLCS Geologist 3). However, interpreting communities' description of the lahar flows is challenging, as is demonstrated below.

Given the differences in water and sediment content between and during lahars (Rodolfo and Arguden, 1991), it is unsurprising that the communities' descriptions of the phenomenon tended to include *'flash flood'*, *'boulders', 'sand', 'lahar', 'debris', 'materials', 'great sound…thumping…rolling boulders…shaking.'* Communities appeared to understand the event as different forms of floods coming down from the volcano. The term lahar was used to describe the material being brought by the 'flood', or to describe the cause of the 'flood':

> '*Lahar is the most contributor of that flood.'* (Rosemarie, Barangay Tandarora)

The terminology may represent a language barrier, with 'flood' being used to describe a largely fluid mass of material coming down from the volcano. But, as noted in Section 6.2, the Reming disaster was accompanied by both flooding and lahars.

[55] For example, the depositional record of the hyperconcentreated flows (PHIVOLCS Geologist 3)

In Daraga, PHIVOLCS Geologist 3 stated that:

> *'as far as we can tell from the description of the flows by the residents, the lahars occurred until Tagas* [downstream of Binitayan] *and everything downstream was like muddy stream flow.'*

Despite the comment from LG Disaster Manager 2 that it is impossible to swim in a lahar, residents of Tagas and Binitayan recalled seeing residents attempting to swim. This observation could reflect the fact that they were initially affected by flooding from the Yawa River (Mirabueno et al., 2006; see Figure 7.3) before the boulder laden hyperconcentrated flow. Binitayan and Tagas were particularly inundated owing to their proximity to the Yawa River, which has several major tributaries flowing into it.

As mentioned previously, some residents apparently chose not to evacuate owing to the assumption that they could wait until they saw the lahar and make the decision then[56]. Such an observation suggests that residents did not fully understand the difference between a fast-flowing lahar and a slow moving lava flow[57] (*cf.* similar confusion amongst civil protection at Vesuvius, Solana et al., 2008). The implication of this confusion is clear: the mitigation, preparedness and response strategies differ significantly between lahars (fast) and lava (slow) flows. The confusion of these terms was anticipated by the researcher owing to her experience of meeting with community members in Barangay Anislag during the 2010 scoping trip. During that meeting communities appeared to use the terms lahar and lava to describe similar phenomena. Therefore, in advance of the first community visits, the researcher asked four key DRR stakeholders [58] whether communities understand the term lahar and if they confuse it with lava flow. The International Volcanologist said that they do use the terms *'interchangeably':*

[56] LG Disaster Manager 2
[57] Indicated during a scoping visit to Barangay Anislag during the September 2010 field visit
[58] International Volcanologist; PHIVOLCS Geologist 1; LG Disaster Manager 1; Programme staff representative (Local NGO B)

> *'they don't distinguish between a lava flow and a lahar as we would – it's just volcanic stuff that comes down.'* (International Volcanologist)

However, PHIVOLCS Geologist 1 stated that the Mayon residents did know the difference, even if they might not use the word lava. This was corroborated by one of the field visits in Tandarora; when asked whether lahar was the correct word to use, Local NGO B programme staff representative said that *'they* – [the community] *are also using the lahar'*. But there was some confusion amongst NGOs as to the difference between flooding and lahar – DRR Point Person (Local NGO A) said that communities in Tabaco (northeast of Mayon) were surprised by the *'lahar'* that inundated them, but only flashflooding and siltation occurred in this area (PHIVOLCS, 2006a).

It was difficult to determine from communities what they believed caused the lahar because they either had trouble answering the question or became shy and embarrassed as they appeared to interpret the question as a test. As a consequence, the questioning was abandoned in later interviews owing to it not being particularly fruitful (similar challenges were experienced by Bowman and White (2012) in their study at Santa Ana Volcano in El Salvador).

Three community interviewees and one community group[59] said that they thought the volcano had erupted during Reming:

> *It came from the volcano – accompanied flood.* (Leja, Barangay Lidong)
>
> *'See cause of it's a combination of two - the Mayon eruption and the typhoon Reming. Two force together hitting Bicol'.* (Rosemarie, Barangay Anislag)

This is in part supported by the fact that two scientists said that they had to reassure some residents that the volcano had not erupted[60].

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[59] Leja and women's group (Barangay Lidong); Rosemarie (Barangay Anislag); Gemma (women's group, Barangay Binitayan)

[60] PHIVOLCS Geologist 3; PHIVOLCS Volcanologist 1

The tendency to assume that the Reming lahars occurred because the volcano erupted might be due to the fact that, according to two scientists, people tended to not associate lahars with periods of low volcanic activity[61] (*cf.* Umbal, 1986):

> *'…did I think that people did not associate lahar with typhoons? I think the answer is probably yes, I think they don't normally associate it with typhoons. And right now they will because that memory is fresh but I don't know how long that is going to last.'* (International Volcanologist)

PHIVOLCS Geologist 1 recognised that residents tend to associate lahars with eruptions but said that PHIVOLCS emphasise to residents that there were some historical lahars that did not occur immediately after an eruption. However, PHIVOLCS Volcanologist 1 said that the *'lahar hazard maps* [are] *being shown during education advocacy for the eruption of Mayon'*, implying that lahar hazard is communicated purely in association with the occurrence of an eruption. Furthermore, the 2000 lahar hazard map gave no indication that lahar hazard could occur with or without a volcanic eruption and that it could occur during a typhoon. Given the frequency of eruption lahars (see Table 6.1, Chapter 6), it is also questionable whether residents would have been likely to associate large lahars with non-eruption triggers.

### 7.5.2 Scientific explanation of the Reming lahars: multiple factors for lahar initiation and distribution

Whilst it was regarded amongst scientists that the reason for the lahars was the intense rainfall brought by typhoon Reming, two localised factors that affected the initiation and distribution of lahars require discussion: the occurrence of landslides in the Masarawag channel and the influence of the 2006 eruption. These factors emphasise the dynamic nature of lahar hazard at Mayon volcano.

[61] International volcanologist; MGB Regional Geologist

**Landslides in the Masarawag Channel**

A phenomenon which was highlighted as being unexpected (and something PHIVOLCS Geologist 3 criticised the published papers for not mentioning) was the occurrence of landslides at the headwaters of the Masarawag channel (see Figure 7.17). These resulted in large lahars inundating barangays Tandarora and Maipon in Guinobatan:

> *'So, if you have landslides the landslide material under heavy rain immediately incorporates into the flow and produces lahars immediately at the higher reaches of the channel. So you have* [these] *huge lahars already very early on. They are just eating down and across the river channels and producing even larger lahars.'* (PHIVOLCS Geologist 3)[62]

The occurrence of these landslides meant that the lahar initiation point was further upslope than had otherwise been anticipated. Under heavy rain, the landslide material was incorporated into the flow of water thereby initiating lahars at higher reaches of the channel. Consequentially, the flows had a longer travel time over which they accumulated more debris before hitting communities. The lahars eroded the upper Masarawag Channel and scoured a new course straight into Maipon and Tandarora (PHIVOLCS, 2007b). As a consequence, the largest number of deaths occurred along the Masarawag channel (PHIVOLCS, 2007b).

[62] International Volcanologist also said that these were significant.


Figure 7.17 View of the Masarawag Reming lahar deposition and buried barangays of Maipon and Tandarora, Guinobatan. The deposition consists of debris flow units with huge boulders. Yellow arrows point to landslides in the Masarawag Channel headwaters which initiated the lahars. View is to the northwest (28 Aug 2007). Source of photo and caption: adapted from PHIVOLCS (2007b: 12).

**The role of the 2006 eruption**

It was generally agreed by the scientists interviewed[63], and mentioned by LG Disaster Managers 2 and 3, that the 2006 eruption did not increase the susceptibility of lahar initiation during Reming as it did not produce any significant additional source material. In fact, the 6.4 km-long lava flow erupted in 2006 was identified as actually mitigating the risk from the particularly high hazard Bonga-Mabinit channel by burying the 2000-2001 pyroclastic deposits emplaced in the Bonga Gully and Mabinit fan (Figure 7.3). The lava flow essentially sealed off the channel, thereby removing risk to Legazpi City[64] (PHIVOLCS, 2006 and 2007a):

> *'for a long time Bonga gully (deepest gully at the time) most of pyroclastic flows have been concentrating in this section – very few have been delivered to the other main channels. So when the 2006 eruption occurred, which brought in mostly ash fall and lava flow, so it actually healed the gully and now most of the water which was*

[63] The scientists who mentioned this were International Volcanologist; PHIVOLCS Geologist 2 and 3; PHIVOLCS Volcanologist; MGB Regional Geologist.
[64] PHIVOLCS Geologist 1 and 2; PHIVOLCS Volcanologist; International Volcanologist

*essentially delivered here also was now shifted to some of the other river channels.'* (PHIVOLCS Geologist 1)

The capping of this gully and its deposits was a significant natural mitigation and demonstrated how previous hazards can reduce rather than amplify the impact of subsequent disasters. However, two other members of local government as well as two NGO staff thought the 2006 eruption was a contributing factor by interpreting it as a supplier of material for the subsequent lahars[65]. This misunderstanding emphasises the importance of good communication and understanding between scientists and decision-makers.

The discussion highlights that communities do not particularly understand lahars as a phenomenon in their own right, viewing them as floods or a product of an eruption of the volcano. In order to anticipate their occurrence, it is therefore necessary to ensure that communities understand the hazards facing them and how these may be triggered by other hazards (e.g. volcanic eruptions or typhoons). A thorough study of the cause of the lahars has been conducted by PHIVOLCS and academics, and it is clear from the PHIVOLCS analysis in particular that there were localised changes that influenced the manifestation and distribution of lahars. These changes emphasise the challenges of lahar hazard mapping and communication on an active volcano.

[65] OCD Regional; LG Disaster Manager 2; Deputy Executive Director (National NGO); Executive Director (Local NGO B)

## 7.6 The multi-hazard characteristics of the disaster: summary and reflection

The multi-method analysis of the case of the Typhoon Reming triggered lahars has identified several multi-hazard aspects to this disaster. The occurrence of the lahars highlighted weaknesses in the anticipation, communication and warning for hazards that trigger secondary hazards. The manifestation of the Reming lahars also demonstrates the challenge of anticipating a secondary hazard that might manifest as a continuum of hazards from initial sediment-rich flooding to boulder laden debris flows. A summary of the multi-hazard aspects of this disaster were therefore the:

- range of hazards during the event (e.g. wind, flooding, landslides, lahars and storm surge) and their different impacts, meaning that homes resilient to one hazard were vulnerable to another (also observed in analysis of the Tōhoku earthquake triggered lahar disaster in Japan, Tweed and Walker, 2011);
- fact that lahars represent a continuum of hazards;
- confusion caused by a single-hazard (typhoon) and single parameter (wind) warning system;
- inability to communicate warnings owing to the damage inflicted by Typhoon Milenyo two months prior to Typhoon Reming;
- influence of different hazards over space and time on both the physical manifestation and spatial concentration of lahars, as well as on DRR stakeholders and communities' perception of risk from Reming;
- fact that it was the secondary hazard (the lahar) that caused the most deaths and not the primary, better anticipated, hazard (the typhoon).

The disaster demonstrates that hazard analyses have to account for the influence of previous hazards in terms of how they may have amplified or created conditions of susceptibility to subsequent hazards. The disaster also demonstrated the limits of communities' memories of previous lahar events as a means of anticipating this disaster. At the same time, however, it challenged the utility of the available scientific mapping and expertise, since scientists were also surprised by the size of this event. Given that the findings reflect the views of a range of stakeholders, a summary of the different views of the four interviewee groups is presented in Table 7.4.

Table 7.4 A summary of the main sub-sections of the case study analysis and discussion, reflecting each group of interviewees.

| Interviewee groups | Was there a warning for lahar? | Did communities evacuate? | Was the event unexpected? | Did this group understand why the lahar occurred? |
|---|---|---|---|---|
| ***Communities*** | No warning for lahar; some felt that the typhoon was not a threat because it was heading for Catanduanes. | At most, moved to a neighbour or family members concrete home but many decided to stay at home. | Some surprised about lahar altogether, very different to what they expect of a 'landslide' or 'flooding'. | Difficult to determine, but communities tend to associate large lahars more with eruptions. |
| ***NGOs*** | No information about the rainfall, confusion about the tracking; feel that the bureaus did not share the lahar 'prediction'. | [Did not specify, but mentioned in general terms that communities do not like to evacuate.] | Did not expect the magnitude of the lahar that occurred. | Mixed – some misunderstood it as being a consequence of the 2006 eruption; some did not specify. |
| ***Local government*** | Gave scenarios to Barangay Captains that included lahars. Feel the problem was that the typhoon warning did not include the rainfall. | Despite trying to warn communities, some decided not to evacuate. | Mixed – essentially beyond the scenarios being adopted | Mixed – two misunderstood it as being a consequence of the 2006 eruption, whereas the others did not. |
| ***Scientists*** | PHIVOLCS: yes there was a lahar warning but PAGASA should have given more information about the rainfall. PAGASA: the responsibility for lahar warning lies with PHIVOLCS. | International volcanologist stated that people stayed in their homes (*cf.* Paguican et al., 2009). | Expected lahars but not of the magnitude that occurred. | Yes – the rainfall and PHIVOLCS conducted extensive analysis into the additional local factors that caused the lahar. |

The following discussion summarises two key themes from the analysis, which are the emergence of interrelated hazards over space and time and the anticipation of the event. The chapter concludes with a summary of lessons from the Reming lahars disaster.

### 7.6.1 The emergence of interrelated hazards over space and time

An objective of part two of the research is to refine the multi-hazard conceptual framework outlined in Chapter 2. Whilst the case study was adopted to explore the hazard interrelation termed ‘causation’, elements of the three other multi-hazard characteristics emerged during the analysis. This emergence reinforces the interdependency of these categories and that multi-hazard assessments need to consider the possibility (if not probability) of these enhancing hazards and subsequent risk.

Whilst there were many socio-economic and political factors that resulted in this disaster, the conceptual framework is largely concerned with the physical influence of previous and simultaneously occurring hazards on conditions of lahar susceptibility. The four categories of hazard interrelations identified in Chapter 2 are compared with the evidence from the Reming in Table 7.5. The findings from the case study emphasise that multi-hazard assessments should not only comprise how hazards might interact to trigger secondary hazards but require the assessment of how hazards in the past have created conditions of increased exposure (volcanic activity concentrated in the south), likelihood (siltation of channels by Typhoon Milenyo) and magnitude (availability of eruptive materials) of future events. These conditions link strongly to the basis of anticipation of geophysical hazards: location, timing and severity (Rees et al., 2012).

Table 7.5 The hazard interrelations identified in the analysis of the Typhoon Reming lahars compared with the conceptual definition of each of these in Chapter 2. The underlined text indicates an update to one of the categories.

| ***Hazard interrelation and definition*** | ***Characteristics of Reming*** |
|---|---|
| **Causation**: *hazards that generate secondary events, which may occur immediately or shortly after the primary hazard.* | The typhoon rains triggered the lahars. |
| **Amplification <u>or alleviation</u>**: *hazards that exacerbate <u>or reduce</u> future hazards.* | Two hazards earlier that year respectively amplified and reduced the physical manifestation of the typhoon Reming lahars: (1) Typhoon Milenyo increased siltation; (2) The 2006 eruption of Mayon actually reduced risk in an area.<br><br>The 1984 eruption changed the directivity of future eruptions thereby concentrating pyroclastic flows and lahar deposits in the southern sector of the volcano.<br><br>[Social characteristics of interacting hazards; Milenyo may have reduced residents' perception of their own risk, ultimately exacerbating the impact of subsequent Reming.] |
| **Association**: *hazards that increase the probability of a secondary event, but which are difficult to quantify.* | The 2000-2001 eruptions supplied the loose volcanic material (PHIVOLCS, 2006a), thereby increasingly the probability of lahars. |
| **Coincidence**: *the simultaneous occurrence of hazards in space and/or time resulting in compounded effects or secondary hazards.* | The fact that there were high winds at the same time as lahars (i.e. the fact that it was triggered by a strong typhoon and not a heavy rainfall episode) hampered relief efforts, thereby compounding the impact of the event.<br><br>[The disaster also highlights the need to consider the possible future coincidental occurrence of a large typhoon and a volcanic eruption and the subsequent lahars this would trigger (see Chapter 8)] |

The evidence from Reming particularly reinforces why community-based assessments of risk must consider time-frames beyond recent memory and geographical analyses that consider influences beyond the community; for instance, the changes in channel configuration upstream of Barangay Padang. The analysis also indicates the role of environmental change and 'non-hazardous' processes on lahar susceptibility. For example, the channel migration upstream of Barangay Padang does not constitute a hazard in itself, but it is a change in the environment that must be taken into context in any hazard and risk analysis. What this case study has reinforced, is why hazard assessments must be reviewed and updated, especially community assessments, since the number of updates required to reflect changes in the official lahar hazard map may be beyond the resources of the government. The change in risk at Barangay Padang occurred between the creation of the 2000 lahar hazard map and the 2006 Reming lahars.

The case study challenged one of the multi-hazard processes identified from the literature review. Amplification is the process by which previous hazards amplify the magnitude and impact of subsequent events (see Table 7.5). However, the 2006 eruption reduced the threat of lahars within a particular channel and largely prevented significant lahar inundation in Legazpi City. As a consequence, the multi-hazard framework should be revised, replacing the term 'amplification' with the duality of 'amplification or alleviation'.

Finally, not only were the lahars triggered by a hazard (typhoon), the disaster also demonstrates the challenge of preparing for and mitigating a secondary hazard that represents a spectrum of hazards from debris flows to more dilute hyperconcentrated flows (a 'compounding event', Lee and Jones, 2004). Communities appeared to perceive lahar as any fast-flowing sediment laden flow coming down from the volcano and prior to Reming some communities were quoted as having believed that they could wait until the flows arrived before deciding whether they could evacuate (Orense and Ikeda, 2007). An important part of DRR in active volcanic areas is therefore ensuring that communities understand that lahars might manifest as highly destructive debris flows (and not simply as 'floods') and that they may occur without an eruption.

The above discussion demonstrates that the characteristics of multi-hazards only emerge by analysing hazard interrelations over different spatial and temporal scales. The findings therefore emphasise that a holistic assessment of multi-hazards requires the analysis of hazard interrelations over space and time. Anticipating these emerged as a major theme within the analysis of the case study and its importance with regard to hazard assessment is discussed below.

### 7.6.2 Anticipation of the event: the role and limits of community knowledge and available science

In spite of the frequent occurrence of lahars, the magnitude of the lahar disaster surprised communities and DRR stakeholders alike. The fact that the secondary hazard (lahar) was not fully anticipated is of particular significance to this research.

Albay is a multi-hazardous province and, consequently, community awareness of hazard and risk was perceived by DRR stakeholders to be high. What Typhoon Reming demonstrates is that community knowledge alone is insufficient for capturing all the dimensions of anticipation: communities had no experience of an event this devastating and therefore had no contingency plan for addressing it. In terms of comparable events, the most recent event of similar impact was the 1875 lahar that inundated the settlement of Cagsawa, which is beyond the living memory of community members. However, 40 people were killed by typhoon (or tropical storm) induced post-eruptions lahars in 1981 (Table 6.1; Chapter 6). As such, the Reming lahars should not have been unexpected, perhaps just deemed unlikely. The findings suggest that Typhoon Milenyo created a 'normalisation bias' amongst residents (and perhaps DRR stakeholders), meaning that were not considering the threat of large lahars from typhoons. It is therefore necessary to consider how communities' (and DRR stakeholders') experiences of earlier hazards and disasters impinges on their ability to perceive that a previously experienced hazard (in this case typhoon) might occur at a greater magnitude than formerly experienced, as well as appreciating the fact that typhoons are capable of bringing large lahars. The occurrence of secondary hazards also emphasises why it is important for communities to understand, at least in general terms, the cause of events and that a large lahar might occur without a simultaneous volcanic eruption. Whilst communities are more aware after Reming, the International Volcanologist expressed their concern that it is challenging to maintain this awareness.

As discussed above, there were a number of means by which earlier hazards and environmental processes increased or decreased the conditions required for the 2006 lahars to occur, which were particularly apparent at the local level. Monitoring these changes necessitates community observers: by communicating these observed changes, areas of increased risk could be identified in a timely manner. There is therefore a need for reciprocated engagement between communities and scientists, so that they alike can understand why risk is either increasing or decreasing.

The case study emphasises the challenge for communities to understand, prepare for and respond to a secondary hazard that represents a spectrum of processes that depend upon the rainfall and conditions of susceptibility (i.e. availability of loose material). As noted earlier, the National NGO representative stated that communities' understanding of the concept of 'landslide' is far from the actual event that occurred. The use of the term 'lahar', therefore, might be misleading as it is understood by communities as any water and debris related flow. Anticipation, however, requires a determination of the type of hazard, its location, timing and severity (Rees et al., 2012).

Lastly, the PHIVOLCS scientists might have been more expectant of lahars but they too were surprised by the sheer scale of this event and the fact that certain areas (like Barangay Padang) would be more gravely affected than others. Part of the problem, as discussed below, was the poor communication of the rainfall, which (it is assumed) they would have used to make an inference about the potential for large lahars. In light of Reming, the role science has to play in the assessment of lahars is further explored in the following chapter.

### 7.6.3 Lessons from Typhoon Reming

As with any disaster, the Typhoon Reming event illustrates a number of problems that could relate to single as well as multi-hazard disasters; for example the failure of the communications systems and the residents reluctance to evacuate. Moreover, it demonstrates how different groups blamed each other for the lack of anticipation and impact of the disaster (Table 7.4).

However, the event also demonstrates that what makes multi-hazard disasters unique is the requirement for DRR systems to anticipate, prepare for and respond to more than one hazard simultaneously, whilst also accounting for how previous different hazards might have amplified or reduced the location, timing and severity (*cf.* Rees et al., 2012) of the anticipated event. DRR in multi-hazard environments therefore needs to be dynamic and flexible as well as regularly reviewed to reflect changes in the environment, along with human factors that influence vulnerability.

The disaster revealed that the typhoon warning system was not particularly well designed to deal with secondary hazards and was criticised for focusing upon only one parameter of the typhoon – the wind. Furthermore, the government's system for monitoring and warning for different hazards is institutionalised and is consequently not well designed to deal with secondary hazards that overlap the mandates of different agencies. Whilst the government agencies are trying to work more succinctly, there was an apparent poor communication and sharing of rainfall information between PAGASA and PHIVOLCS and with the local government, NGOs and communities.

The problem appears to be that post-eruption lahars fall into a gap between volcanic and flood hazards, at least to some extent, both in terms of awareness and institutional responsibility for monitoring and warning. Furthermore, the fact that the event occurred five years after the last significant eruption means that large lahars were not on the radar of even the DRR stakeholders. Indeed, similar to local communities, it appeared as though the local government officials based their preparedness measures for the typhoon on their past experiences of dealing with these events.

In the aftermath of Typhoon Reming, PHIVOLCS recommended, amongst other things, that there was a need to 'review and reassess future lahar and flood hazards based on impacts of the Super Typhoon Reming…and develop…[or] strengthen…community-based early warning system[s]' (PHIVOLCS, 2006a: 19). Additional recommendations included engineering interventions, evacuation procedures, resettlement of high risk communities, land use zoning and the improved resilience of the communication systems for warning PHIVOLCS, 2006a). Complementing and in addition to these, the analysis of the case study in this chapter has identified the need for:

- local level hazard assessments;
- constant review of hazard assessments;
- lahar hazard assessments that count for multi-hazard triggers of lahars;
- awareness raising amongst communities and some decision-makers as to the cause of lahars and the factors that influence susceptibility to lahar;
- improved anticipation of the magnitude of lahar events.

Underpinning each of these recommendations is the rigorous assessment of lahar hazard and the timely anticipation of lahar events. The following chapter explores the methods of lahar hazard evaluation and whether they incorporate the recommendations above, as well as a multi-hazard approach.

# Chapter 8: An evaluation of scientific methods for assessing lahar hazard at Mayon

Chapter 8 presents a critical evaluation of the current methods utilised for scientifically assessing and anticipating lahars at Mayon volcano. The objectives of the evaluation are to identify the extent to which these methods (1) anticipate future lahars and (2) adopt a multi-hazard approach. The reason for carrying out this evaluation was owing to the emphasis on anticipation within the case study analysis. Furthermore, the earlier chapters have emphasised the need for, and barriers to, the integration of science, so the opportunity to evaluate the available science (using the example of lahars at Mayon) builds on these findings. The chapter does not represent an exhaustive critical evaluation, but instead an interpretation of the secondary information regarding lahar hazard assessments made available during the field work. The analysis is supplemented where possible by interview data; however it primarily represents the researcher's interpretation of the available maps and rainfall data, based on the information provided alongside these.

The chapter begins with an introduction to lahar hazard assessments, before critically evaluating the two primary methods adopted for lahar assessment at Mayon: lahar hazard mapping and critical rainfall threshold analysis. The evaluation of the lahar hazard assessment is followed by a review of the general level of engagement between NGOs and scientists, informed by the analysis of interviews conducted during the October-November 2012 field visit. The chapter concludes with a summary of the utility of current scientific methods for anticipating lahar hazard in the context of multi-hazards.

## 8.1 Assessing lahar hazard at Mayon Volcano

The Reming lahars disaster indicated the need to better anticipate the severity of possible lahar disasters. It also illustrated that the worst-case scenario planning by the government scientists and local government had not accounted for an event similar to the magnitude of the Reming lahars. Since the disaster, the lahar hazard map has been reviewed, the government has begun utilising a critical rainfall threshold approach to the issuing of evacuations and a number of communities have been relocated away from the hazard zones identified in the lahar hazard assessment (e.g. the residents interviewed in Barangay Anislag).

### 8.1.1 Introduction to lahar hazard assessments

The conditions that increase the likelihood of mass movements can be grouped into three types of factors (Lee and Jones, 2004):

(1) preconditioning factors (e.g. slope steepness)
(2) preparatory factors (e.g. abundant unconsolidated debris and an adequate water source)
(3) triggering factors (e.g. heavy rainfall)

The first two factors create conditions of susceptibility, whereas the third is what triggers the (in this case) lahar event. Each of the three factors may be influenced by other hazards; for example the rainfall triggering might be associated with a typhoon. Lahar hazard assessments should therefore incorporate the analysis of multi-hazard processes and interrelations when considering each of these factors.

Lahars and mass movements in general are assessed in terms of the identification of areas of different levels of threat and the location, timing and magnitude and character of individual events (Lee and Jones, 2004; Vallance, 2005; Rees et al., 2012). Anticipating individual events relies heavily on monitoring and modelling and is the basis for developing early-warning systems (Lee and Jones, 2004); it also includes the anticipation of the events that trigger lahars, for example volcanic eruptions and heavy rainfall (Vallance, 2005). Areas susceptible to lahars are identified by the mapping of existing deposits and by applying theoretical models of lahar inundation (Vallance, 2005). More recently, lahar and mass movement hazard and risk assessments have become increasingly probabilistic in their approach to the determination of occurrence and magnitude of these hazards (Jakob, 2005; Hincks et al., 2013).

After the 1984 eruption, numerous studies of lahar initiation were carried out at Mayon (see Okkerman et al., 1985; Umbal, 1986; Rodolfo et al., 1989; Arguden and Rodolfo, 1990; Rodolfo and Arguden, 1991). Since then, the two main approaches to scientific lahar hazard assessment are lahar hazard mapping (and modelling) and critical rainfall threshold analysis. These approaches are evaluated in turn below.

### 8.1.2 Lahar hazard mapping and modelling at Mayon

In their description of the lahar hazard map, PHIVOLCS (2006a) note that:

> The PHIVOLCS lahar hazards assessment aims to determine where and when future lahars will occur and their potential severity. Its end products are lahar hazard maps that ***"strive to present severe but reasonable prediction for planning purposes"*** (Pierson et. al., 1992 *in* PHIVOLCS, 2006a: 1).

The implication in the above quotation is that the hazard map contain all three components of anticipation given the emphasis on 'where' (location) and 'when' (timing) lahars might occur, as well as their 'potential severity' (magnitude). However, as noted in Chapter 7, the map indicates areas that are relatively more or less prone to lahar inundation, but determining when these might occur and how severe they might be is down to user interpretation since return periods are not stated (see Figure 7.14; Chapter 7). The implication is that areas of low proneness are expected to be affected only by high-magnitude (Reming sized) lahars, but this is not explicitly stated in the map. In contrast, for example, the volcanic risk map for Taranaki volcano in New Zealand provides clarification for its low risk areas by describing them as being 'affected by lahars and debris avalanches during huge isolated events' (Taranaki Regional Council, 2014). The challenge of mapping areas that are inundated by high magnitude, low probability events means that a degree of expert judgement is required:

> *'it* [the map] *has a lot of other…shall we say expert additions … it is very difficult to model the low hazard…that can only become susceptible, vulnerable to lahars when there are extremely large, very rare events – like lahars that are produced by Reming, rainfall that exceed the hundred year or maybe two hundred year…so we make reasonable assumptions on where these areas are.'* (PHIVOLCS Geologist 3)

PHIVOLCS Geologists 1 and 2 described the basis of lahar mapping as the combination of mapping *'geology, geomorphology…and historical events'*. PHIVOLCS state that they frequently update hazard mapping and assessment, particularly after a major volcanic eruption or lahar (PHIVOLCS, 2006a). In 2011, the lahar hazard map was updated to reflect changes in topography (Figure 8.1). The revised hazard map incorporates deterministic modelling of lahar hazard utilising the LAHARZ programme. The fact that it only requires one input parameter – lahar volume – and a reliable digital elevation model (DEM) makes it an appealing means of modelling lahars in countries where resources for science are limited:

> *'typically a full hazard scenario would involve…frequency maybe or some form of weight based on several factors like availability of source material, morphology of the slopes, the proximity of the river bed to erodible material, so many others things, vegetation cover, possibility of tributary change or transition in the upper slopes; and you could probable come up with hazards map – but who has time to do all of these assessments?'* (PHIVOLCS Geologist 3)

The LAHARZ software is based on the statistical analyses of 27 lahar-inundation paths from nine volcanoes across the world (including Mayon), which resulted in semi-empirical equations that predict the valley cross-sectional area (A) and planimetric area (B) inundated by lahars of a given various volume (V) (Iverson et al., 1998):

$$A = 0.05V^{2/3} \quad (1)$$

$$B = 200V^{2/3} \quad (2)$$

The software runs with a Geographical Information System (GIS) using these equations to provide an automated method to estimate areas of potential lahar inundation (Schilling, 1998). Using a DEM and several user-defined lahar volumes, LAHARZ applies equations (1) and (2) to user-selected stream drainages to generate a series of nested lahar inundation zones (Schilling, 1998). The volume of lahar (V) is specified by the user and LAHARZ constructs the paths of lahar-inundation that extend to where the energy line intersects with topography (Schilling, 1998). The energy line describes how the initial potential energy of a lahar is consumed by friction during travel. Measured from the top of the unstable slope, the energy line intersects the ground where the potential energy has been consumed and the lahar comes to rest. The value of the energy line is determined by means of the ratio between the vertical drop (H) and horizontal runout (L) (Schilling, 1998).

LAHARZ is not designed to account for gradual rainfall triggered lahars, only 'sudden-onset' lahars including those that evolve from ice avalanches, pyroclastic flows or lake-breakout floods originating high on the volcano flanks (Iverson et al., 1998). It also tends to display 'ragged' lahar zone edges owing to the built-in working assumption that the initial lahar volume remains constant, thus not accounting for the bulking and debulking that characterises lahars in motion (Muñoz-Salinas et al., 2009). In spite of these limitations, LAHARZ has been used to model lahars at Mayon to include the Reming lahars as '*one of the worst historical* [scenarios]' (PHIVOLCS Geologist 2). LAHARZ cannot account for lahar mitigation, but PHIVOLCS Geologist 2 said that they assume that the dikes fail during these types of events regardless.

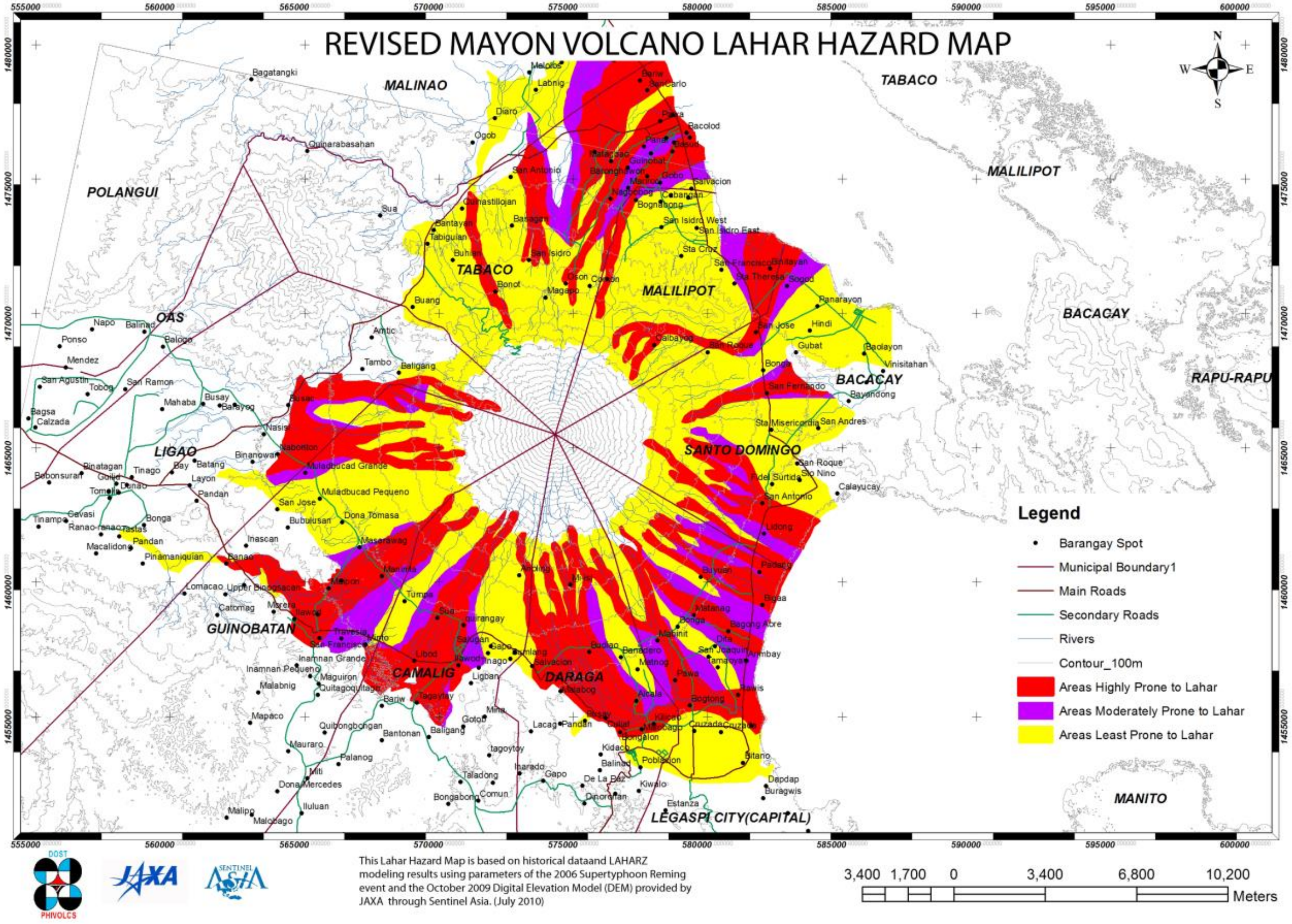


Figure 8.1 Revised lahar hazard map (2011) incorporating LAHARZ modelling. Source: PHIVOLCS (2011b).

One of the PHIVOLCS interviewees made it clear that the map update was not an admission of any fault during Reming:

> *'it was after Reming, well we didn't do it as a revision per se because we feel that our maps are not sufficient, we were just applying present day topography to find out if there will be significant changes to where the delivery of flows were and in fact it didn't change.'* (PHIVOLCS Geologist 1)

Comparing the 2011 map with the previous update in 2000, the areas threatened by lahar hazard largely remain the same; however the 'highly prone' areas have expanded to include some of the downstream areas that were affected by the 2006 lahars (Figure 8.2). By making these areas highly prone, there is an underlying assumption that they will be frequently inundated by lahar. However, these areas were only hit during Reming because the lahars and associated flooding were of sufficient size to affect areas far downstream. For instance, the mouth of the Yawa River (D; Figure 8.2) was not included in the 2000 hazard zonation because it was *'off the radar screen'* (International Volcanologist, 2012). Likewise, as observed by PHIVOLCS Geologist 3, there were some areas covered by the map that the scientists did not anticipate would actually be more dangerous than neighbouring areas, for example Barangay Padang. The highly prone zones have been extended in these areas, as well as downstream of Guinobatan, Daraga and Camalig (Figure 8.2). From the interpretation of the map, three possible reasons for these adjustments are postulated; the first might be due to the utilisation of LAHARZ and, consequently, a 10m DEM (ALOS was used according to PHIVOLCS Geologist 2) and concentrated modelling in the southern sector owing to the availability of volcanic material from recent eruptions compared with the northern sector. The second reason might be owing to the hazard interrelation of 'amplification', where the influence of the Reming lahars on the topography has altered channel configuration meaning that some areas are now much more susceptible to future lahars; for example, the new path for lahar flows directly into Padang. However, as discussed in the following section, these localised changes in drainage can be short-lived, whereas the map is designed to reflect the long-term hazard.

The third reason for extending the areas highly prone to lahar might also be owing to the adoption of a conservative approach, which may be a consequence of the controversy surrounding the institutional responsibility for warning communities about the impending lahars during Reming. Some barangays re-classed as highly prone are described as at risk from 'possible' avulsion and some of these areas include Barangays at risk from secondary events triggered by lahar. For example, Barangay Libod in Camalig (Figure 8.1; B) is now within the high proneness area yet it is described as only being at risk from 'potential flooding and siltation from related lahar events; possible washout along riverbanks' (PHIVOLCS, 2006a: 9). During Reming, this barangay was affected by flash-flooding and siltation driven by the lahars, but was not directly inundated by lahars, (PHIVOLCS, 2006a). It appears, then, that this Barangay is actually at risk from flooding caused by lahars, but possibly only during extreme events, which makes the classification of 'highly prone' ambiguous. Owing to limited resources, it may be necessary to adopt this conservative approach to hazard mapping, rather than try to maintain the frequency of required updates.

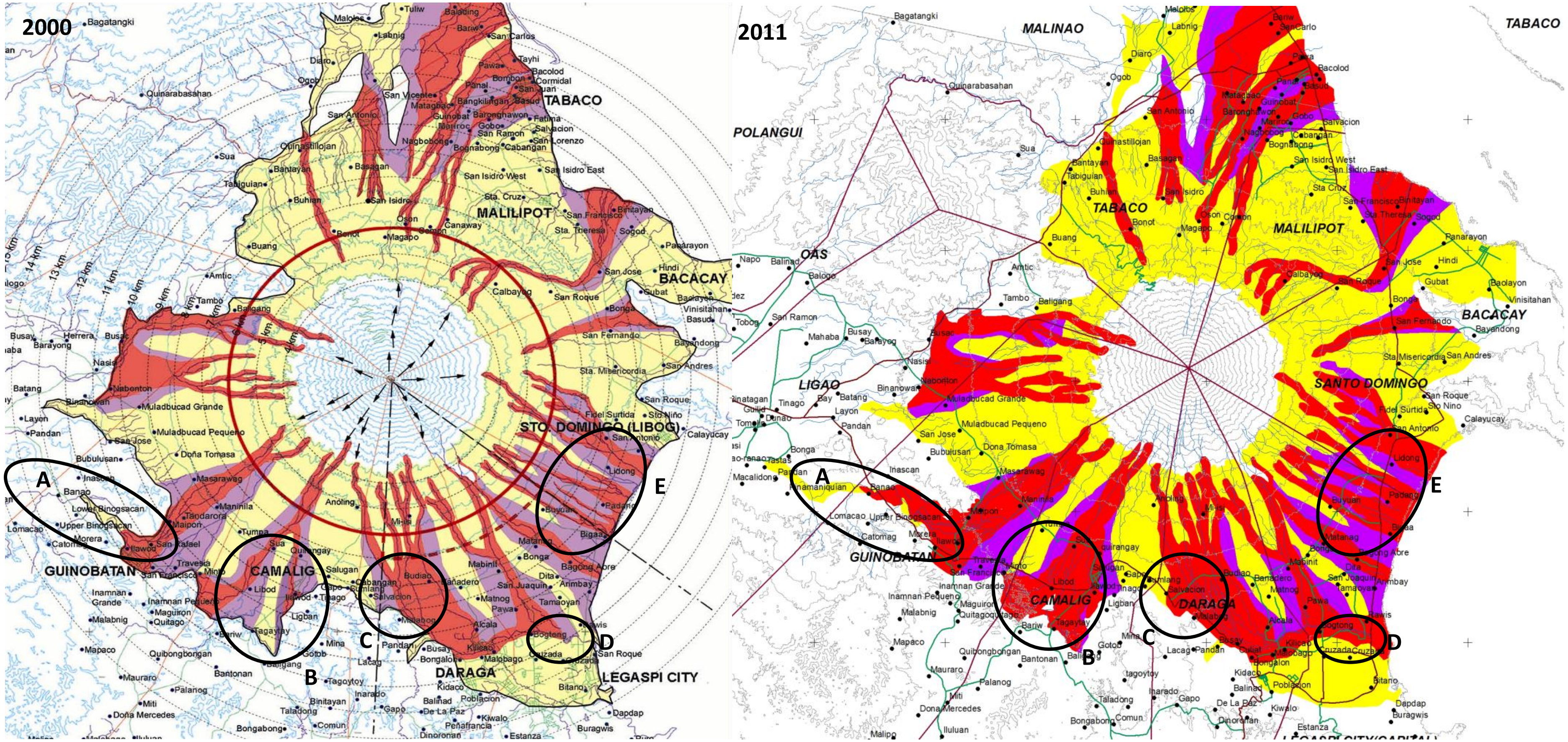


Figure 8.2 Comparison of the 2000 and 2011 hazard maps. The black circles indicate the areas where the zones of high proneness to lahar hazard have increased. A: downstream areas of Guinobatan; B: downstream Camalig; C: upstream Daraga; D: the mouth of the Yawa River; E: Barangays Padang, Lidong and San Isidro. Source: maps cropped and adapted from PHIVOLCS' original maps (2000 and 2011b).

As observed in the analysis of Reming, a major challenge in mapping a dynamic environment like Mayon is that lahar proneness changes in the short-term and that it might not be possible to reflect this in a long-term hazard map. For example, PHIVOLCS Volcanologist 1 felt that the risk of lahar had actually lessened after Reming owing to the fact that most of the loose volcanic material is now in the depositional area and the recent eruptions have not provided much replenishment. In contrast, a representative of local government perceived the '2006' and '2010' eruptions as having replenished source material for lahar generation. The difference in opinion between these two interviewees demonstrates the need to communicate how factors in the short to medium-term might increase or reduce risk. This emphasises why engagement between scientists, decision-makers and communities is essential. As was identified in Chapter 4, communities and NGOs are especially concerned with hazard, vulnerability and risk at the local level. The following section describes the measures that have been adopted in order to map lahar hazard at this local scale.

**Community-scale maps**

Preparing maps of lahar hazard at an active volcano is complicated by the fact that eruptions do not replenish the volcanic edifice equally with new source material in the short to medium-term (years to decades; Rodolfo and Arguden, 1991), which are the scales of concern to local communities (see Chapter 4). The challenge of updating the map is also owing to the fact that:

> *'…the current topography, by the way, of the volcano…is always changing!'* (PHIVOLCS Geologist 3)

Together, the changing patterns of drainage[1] as well as fluctuations in the availability of source material for lahars mean that hazard is spatially diverse in the short- to medium-term. The lahar hazard map depicts lahar proneness in the long-term; it is thus most appropriate for long-term planning and maintaining awareness amongst residents around the volcano but

[1] Also noted by LG Disaster Manager 2

perhaps less so for preparedness activities in the short-term. Indeed, the 2000 map contains the following caveat:

> Hazard zonation is subject to change in the event of change(s) in the configuration of the crater rim. Hazard zone limits are approximated based on data from historical medium-scale eruptions and may be exceeded during larger-scale Plinian eruptions (PHIVOLCS, 2000).

However this statement is deliberately vague because, as noted by PHIVOLCS Geologist 3, it is impossible to determine what the change might be. The 2000 map did indicate a segment where, owing to the notch in the crater edge, there is increased susceptibility of 'pyroclastic flow-generating events' in this area.

Over time, communities may need to be reminded of the relative differences in hazard proneness, which may not be reflected in the hazard map over the short- to medium-term. It is speculated that such information may be expressed during Information Education Campaigns (IECs), however PHIVOLCS Geologist 1 described these events as targeting Barangay Captains, Mayors and Governors and did not mention NGOs or wider community members. Local-scale mapping provides an opportunity to evaluate and communicate short-term changes in lahar hazard. The large-scale hazard maps that have subsequently been produced have focused on the southern sector, which suggests concerns regarding the current greater availability of source material in this sector.

A review of hazards at regular intervals is a key, but often overlooked, component of NGO community-based hazard assessment (see Chapters 4 and 5) and the Reming disaster emphasises why this revision is so important. Following the 2006 lahars, PHIVOLCS conducted detailed mapping of Camalig, Daraga and Legazpi City at a 1:75,000 scale (PHIVOLCS, 2007). The mapping was supported by modelling with LAHARZ and indicated increased risk to barangays in the vicinity of the Mabinit Lahar fan (Figure 8.3). The analysis identified that future lahar scenarios in the Buyuan-Padang Channel will bypass Buyuan and flow into Barangay Padang and, also, that the dredging works are increasing risk to the unaffected barangays adjacent to the new fan of lahar deposits. Such local analysis provided insightful information to 'aid in risk reduction and land use planning activities of the local government and other concerned organisations' (PHIVOLCS, 2007: 16). In addition, PHIVOLCS conducted hazard surveys across eight municipalities around the volcano (see PHIVOLCS, 2006a). The report outlining these surveys is, however, an internal PHIVOLCS document shared with the researcher, which implies that it may not automatically be available to an NGO or community without a specific request.

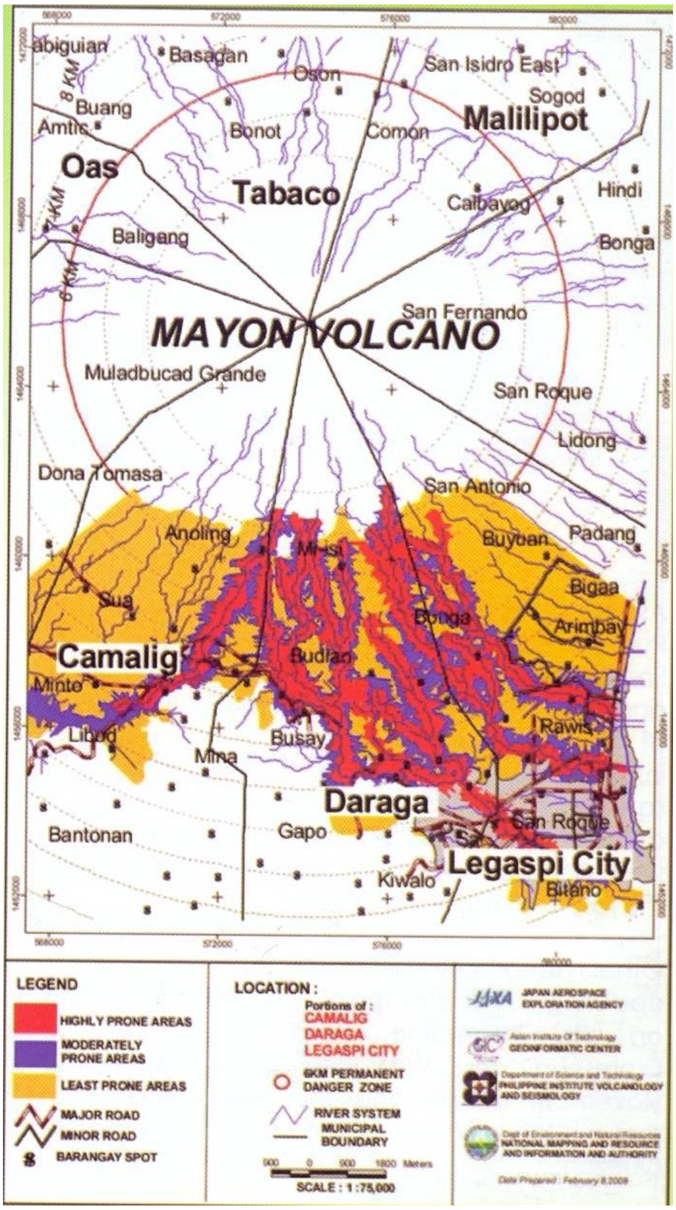


Figure 8.3 Lahar hazard map for Camalig, Daraga and Legazpi City. Source: PHIVOLCS (2008b).

After Reming, localised lahar hazard mapping was also commissioned by a consortium of NGOs, implemented by Manila Observatory (MO) and the University of the Philippines National Institute of Geological Sciences (UPNIGS). They prepared lahar hazard and risk maps of barangays on the southern sector of Mayon (Figures 8.4 and 8.5).

The map scores zones of lahar hazard as a function of the area of the lahar deposits and proximity to the lahar path, weighted depending upon the type of lahar zone, such as whether the area is within a historical lahar path or at predefined distances from this path and at slopes $<30^o$ in angle (MO and NIGS, 2009). Risk is determined by combining this score with exposure data (population density) and a vulnerability factor based upon poverty. When combined with these data, some of the areas of very low hazard average as being at high risk (Figure 8.5). The map states that areas of high risk equate to both high exposure and high poverty. However, as Reming demonstrated, high-magnitude lahar events impact both the rich and the poor and so questioning whether poverty is too simplistic as a measure of vulnerability. The differences between the hazard and risk maps illustrate why communication of the hazard, exposure and vulnerability behind the map is so essential.

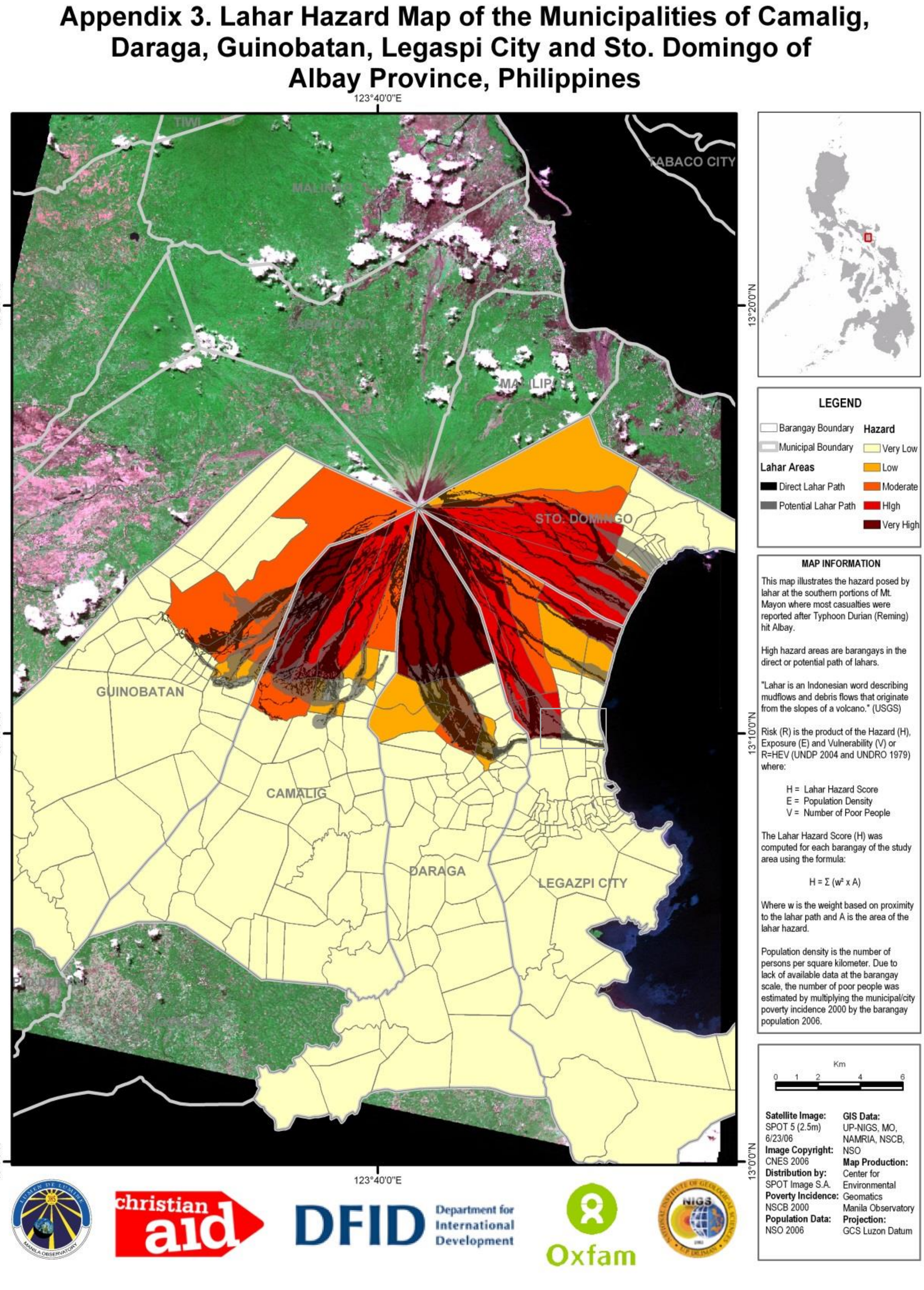


Figure 8.4 Barangay scale lahar hazard map created by a consortium of international NGOs and local scientists from the University of the Philippines National Institute of Geological Sciences (UPNIGS) and the Manila Observatory (MO). Grey box indicates the mouth of the Yawa River. Source: MO and UPNIGS (2009).

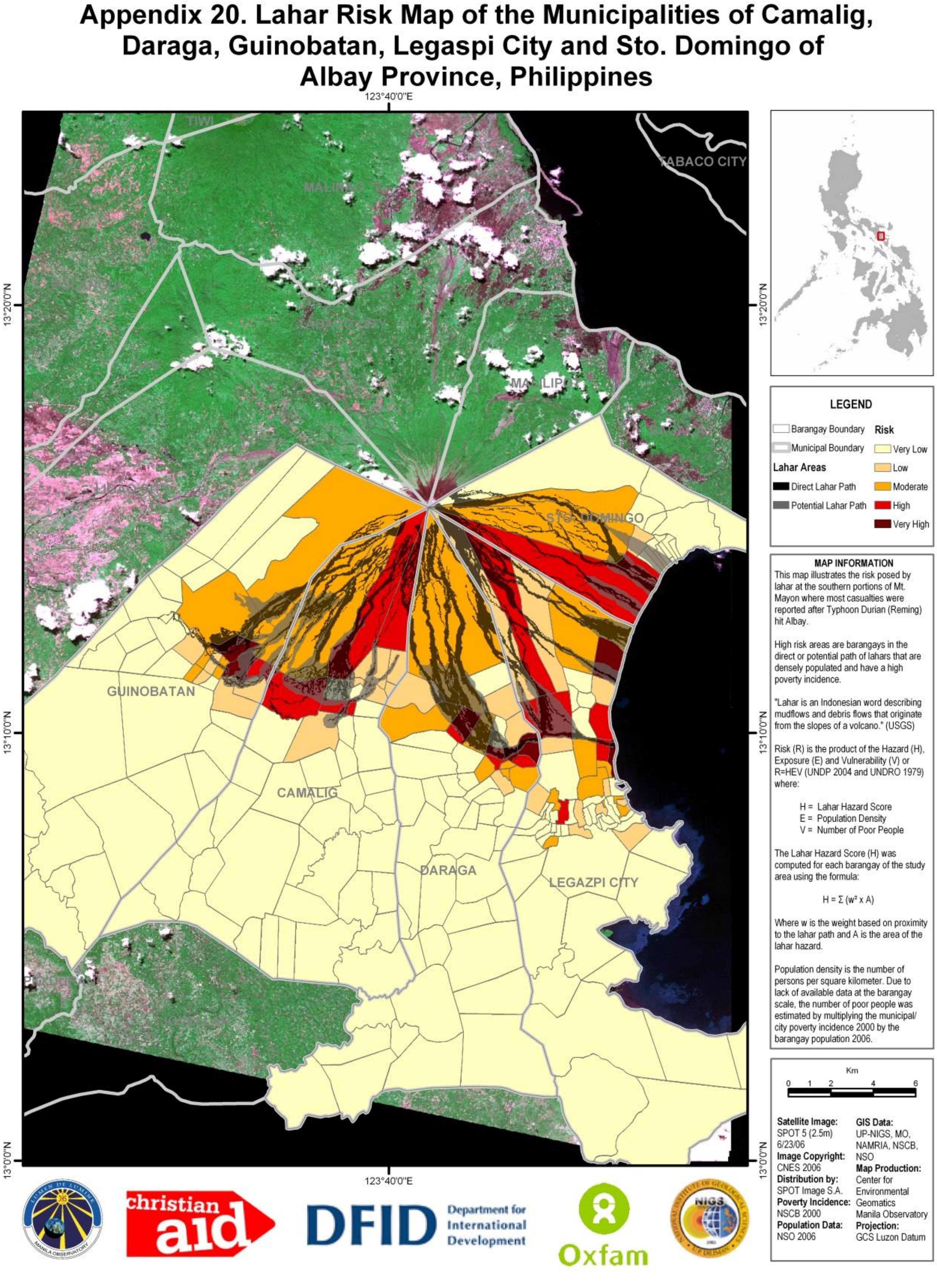


Figure 8.5 Barangay scale lahar risk map created by a consortium of international NGOs and local scientists from the University of the Philippines National Institute of Geological Sciences (UPNIGS) and the Manila Observatory (MO). Source: MO and UPNIGS (2009).

The MO-UPNIGS lahar hazard map (Figure 8.4) does not extend the high hazard zonation to the lower reaches of some of the channels, for example the Yawa River, compared with the 2011 PHIVOLCS map. The PHIVOLCS map therefore appears to adopt a more conservative approach, and may explain why PHIVOLCS Volcanologist 2 expressed concern over the utility and utilisation of maps that they have not created. However, the MO-UPNIGS maps provide a lot more explanation regarding how they were created, whereas the PHIVOLCS maps leave much to the interpretation of the user. When asked whether they had seen and were using the MO-UPNIGS maps, PHIVOLCS Volcanologist 1 and LG Disaster Manager 2 recognised its contribution but said that it was not being used:

> *'the hazard map that NIGS and Manila Observatory is being offered to Albay but Albay rejected – they did not use it, maybe they accepted but they are not using it because they* [NIGS and Manila Observatory] *are not the mandated government agency to do it.'* (PHIVOLCS Volcanologist 1)

Additionally, LG Disaster Manager 2 stated that the MO-UPNIGS map is *'already outdated'*. PHIVOLCS Geologist 3 also voiced some frustration about this work, particularly because they had not collaborated with PHIVOLCS:

> *'we were beaten to* [publishing about Reming] *by a consortium of the University of the Philippines and two NGOs – Oxfam and Manila Observatory – so they were doing… the kind of work that we were doing, and they came up with an entirely different set of data that they immediately published. …that work could have been done much better if they had sought collaboration with us…because they actually had no recent experience in Mayon. …we're quite familiar with what the volcano looked like before and after this event so this is kind of a shame. And of course, yes this conclusion that the dikes contributed to the hazard and the impacts is absolutely not true.'* (PHIVOLCS Geologist 3)

The availability of different maps emphasises the need for NGOs (and decision-makers) to be able to make an informed decision regarding the suitability (and credibility) of the science they are applying to their work. Understanding these maps might necessitate consultation with scientists; however there is contention regarding the source of that science: whether it is government or non-government.

**Anticipating lahar hazard through mapping and modelling: reflection**

A critical evaluation of lahar hazard (and risk) mapping for Mayon has identified seven main points. First, the 2011 lahar hazard map for Mayon volcano adopts a long-term relative ranking of hazard approach, but does not attempt to quantify the return period or likelihood of lahar occurrence or impact. The classes of hazards may be confusing for end-users, particularly the class of low lahar proneness, since these areas might not be often affected but when they are it is likely to be devastating. Mapping lahar and volcanic hazards is generally challenging owing to the number

of factors that require assessment and the uncertainty regarding changes in the morphology of the volcanic crater and, therefore, the primary direction of pyroclastic and lahar flows and, likewise, when these might be resupplied. Owing to these challenges, it appears that a largely conservative approach to hazard mapping has been adopted, although this does not appear to have been based on scenarios greater than the Reming lahars. Expert judgement is required to map the low hazard areas for extreme lahar events – like those triggered by Reming – therefore decision-makers might need to consult with these experts in order to fully understand local levels of hazard. The challenge of monitoring changes in lahar proneness across channels (as occurred prior to Reming) emphasises the need for scientists to communicate with local government, NGOs and communities, as well as for communities to share their observations of changes in their environment with scientists.

The analysis has revealed problems owing to lack of collaboration between academic and government scientists (and NGOs), issues of trust across these groups and the challenge of ensuring that non-scientific decision-makers utilise credible science when at least three different lahar maps exist: two hazard maps and one risk map. These concerns need to be addressed in the context of ensuring improved engagement between scientists and NGOs.

The PHIVOLCS map serves as means for long-term planning and designing policies of relocating high-risk communities. However, hazard proneness is not only dictated by topography and the availability of source material, but also the occurrence of a sufficient intensity of rainfall, which can vary from catchment to catchment, particularly during regional storms (Rodolfo and Arguden, 1991). As noted by PHIVOLCS Geologist 2, LAHARZ utilises the volume of previous lahars, but does not reflect the triggering rainfall. The 2011 lahar hazard map largely considers preparatory factors (i.e. topography), but not preconditioning factors (e.g. the availability of volcanic material) or triggering factors (e.g. intensity of rainfall). Although the increased areas of proneness in the southern sector indicate that the availability of volcanic material may have been considered in the 2011 update. Furthermore, in the context of multi-hazard assessments, the lahar hazard does not explicitly state the threat of lahars during periods of repose.

Disconnect exists between the anticipation of location and severity of lahar hazard and its triggering mechanism. Three scientists[2] noted that it is not necessary to map more than one hazard (*cf.* Kappes et al., 2012):

> *'eruption with typhoon: that will take care of the lahar because it covers water related-hazard. Don't really show a map* [of] *lahar induced by typhoons.'* (PHIVOLCS Geologist 2)

Nevertheless, it is important to ensure a link between known rainfall and scenarios for lahar inundation. Many residents have been allocated housing in the relocation barangays, but they still depend on areas in the high hazard areas for their livelihoods and will continue to return[3] (Usamah and Haynes, 2012). In order to maintain their 'zero casualty' target, the government

[2] MGB Regional Geologist; PHIVOLCS Geologists 1 and 2
[3] Also mentioned by Perla (Barangay Sua)and interviews with residents in Barangay Tandarora

implement pre-emptive evacuation and, as such, timely warning of rainfall-triggers of lahar is an integral part of anticipating lahar hazard in the short-term. The following section evaluates this method.

### 8.1.3 Critical rainfall intensity thresholds: anticipation of lahar triggers and timing

The timing of lahar occurrence in the short term at Mayon is primarily anticipated using critical rainfall thresholds. The volume of rain required to trigger a lahar is dependent upon whether the deposits are wet or dry, the porosity of the deposits, the angle of slope, the vegetative cover and the intensity of the rainfall (Okkerman et al., 1985; Yumul et al., 2011). The following discussion focuses upon rainfall intensity, since it is this parameter which is used as a basis for lahar evacuation at Mayon volcano.

**Introduction to critical rainfall thresholds**

Rainfall thresholds are frequently used to anticipate the occurrence of shallow landslides and debris flows (Guzzetti, et al. 2008). Caine (1980) was the first to model average rainfall intensity-duration thresholds (Guzzetti et al., 2008) and, using data from several locations around the world, proposed a general relation between rainfall intensity (I; mm/hour) and duration (D; hours) of the form:

$$I = aD^{-b} \tag{3}$$

Where the constants *a* and *b* describe the particular data set analysed. In Caine (1980)'s study the critical threshold was described by:

$$I = 14.82D^{-0.39} \tag{4}$$

The premise behind Caine's work is that a triggering rainfall threshold is defined by the total depth of rainfall and the instantaneous rainfall intensity. Caine used the record of rainfall intensities and durations that triggered 73 debris flows on previously undisturbed slopes (the locations of which are not specified); however, rainfall conditions that did not trigger landslides were not considered, so the derived threshold incorporates only part of the evidence (Wieczorek and Glade, 2005).

A similar analysis was carried at Mayon volcano in the 1980s. Rodolfo and Arguden (1991) recorded 79 rainfall events across the two channels (23 in the Mabinit Channel from 1986 and 1987 and 56 within both the Basud and Mabinit Channels in 1988 and 1989; see Figure 7.3 for channel locations) and 14 of these rainfall events triggered a total of 16 debris flows (see Figure 8.6). These all represent post-eruption lahars (the most recent eruption had occurred in 1984).

The study by Rodolfo and Arguden (1991) is based on significantly fewer data points than Caine's analysis. In order to determine a rainfall intensity-duration threshold the authors plotted the data on a log-log graph, determined the least-squares regression line for the 14 events (in dots; Figure 8.6), and then drew a line parallel to it through the five minima. Manually tracing these relationships is common practice, but this method has recently been criticised in favour of more probabilistic approaches (see Berti et al., 2012). Nevertheless, the data show that, for a given duration of rainfall, debris flows are expected in the Basud or Mabinit channels when the rainfall intensity exceeds critical values:

$$I = 27.3D^{-0.38} \quad (5)$$

This suggests that the coefficient *b* in equation (5) is almost double the value postulated by Caine (1980). Rainfall intensity is the average rate of rainfall that fell over the entire triggering event (the rainfall that falls up until the failure of the slope), whereas the maximum accumulation over a 10 minute period is a measure of maximum short-term rainfall intensity.

Based upon the pattern of the 14 rainfall events that triggered debris flows, Rodolfo and Arguden (1991) proposed that the following additional criteria needed to be satisfied before debris flows were triggered (Figure 8.6):

- rainfall of 40 mm in 1.4 hours or longer and
- a minimum of 40 mm of rain delivered at an overall rate of at least 11 mm/hour,
- with 10 mm or more falling during the most intense 10 minutes (Okkerman et al., 1985; Lavigne et al., 2000)

However, as demonstrated in Figure 8.6, meeting these criteria does not mean that a debris flow will be initiated as both hyperconcentrated and flooding events (and, in the case of 40mm in 1.4 hours criterion, 'no flows') were also recorded above these thresholds. Since Rodolfo and Arguden (1991) have given no indication of the effect of the passage of time in their figure, it can only be speculated that these events may represent the depletion of available volcanic material. Those events that required the greatest volumes or intensities of rainfall tended to be debris flows.

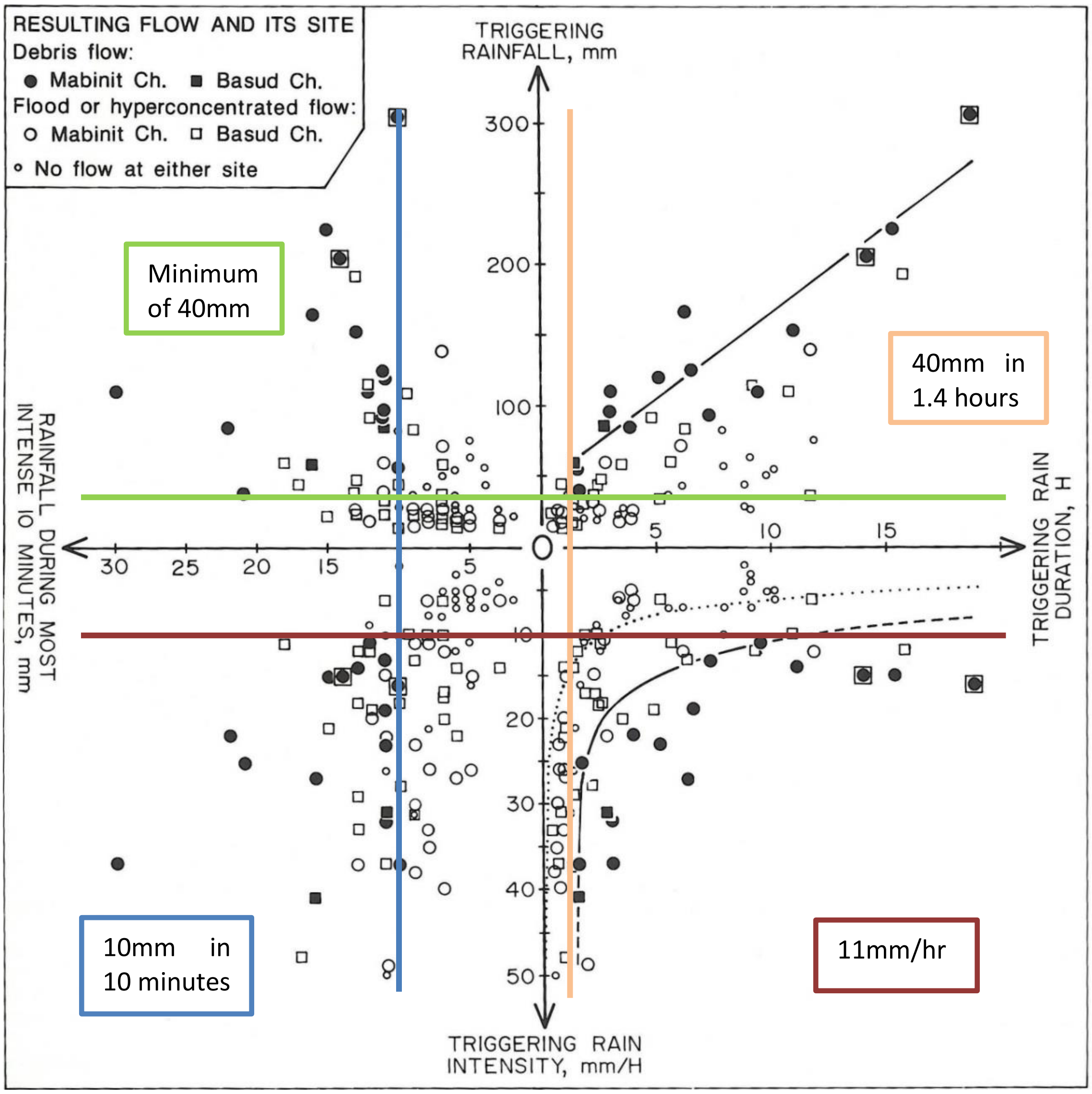


Figure 8.6 Critical rainfall parameters that resulted in debris flows in the Mabinit and Basud Channels. The coloured lines were added to illustrate the additional rainfall criteria noted by Rodolfo and Arguden (1991). Source: adapted from Rodolfo and Arguden (1991, fig.4: 76).

After Reming, the local government began utilising critical rainfall thresholds for lahars[4] (in addition to landslides and flooding):

> *'And the only official authority on warning is PAGASA – we are not authorised – but in the absence of PAGASA we will do it.'* (LG Disaster Manager 2)

[4] LG Disaster Manager 2 (email correspondence, 7th March 2014)

There are two thresholds for lahars: one for evacuation and one for lahar initiation. The utility of these thresholds depends on the forecast and monitoring of hourly rainfall intensities. The critical rainfall threshold for lahar occurrence is 150 mm of accumulated rainfall at a rate of 60 mm/hour (with extreme events occurring at 68 mm/hour), but residents will be evacuated if the threshold reaches 40-45 mm/hour in order to ensure a *'lead time of one to two hours'* (LG Disaster Manager 2). LG Disaster Manager 2 stated that the threshold was based on studies by meteorologists, geologists the interviewees' experience of previous events. What is perceived to be most important is the intensity threshold:

> *'But if it is continuous but not as big as the threshold of mudflow, even if it is continuous, without reaching...50 or 60mm per hour there's no lahar…because the volume cannot guarantee for the mobilisation of it.'* (LG Disaster Manager 2)

In addition to the threshold being adopted by the provincial government, PHIVOLCS also have their own threshold criteria: 200 mm of accumulated rainfall in 24 hours (PHIVOLCS, 2006a). According to PHIVOLCS Volcanologist 1:

> *'What* [the local government] *use is what PHIVOLCS* [are] *using based on experiment of Rodolfo….'* (PHIVOLCS Volcanologist 1)

In terms of the PHIVOLCS threshold, applying Rodolfo and Arguden's (1991) equation (5) to a 24 hour period gives a critical mean intensity of 8.16 mm/hour which, over 24 hours, yields a rainfall volume of 196mm. If the local government's threshold is also based on Rodolfo and Arguden (1991)'s analysis, it is postulated that the value of 60 mm/hour is derived from the criterion that 10 mm (or more) must fall within the most intense ten minutes (see Rodolfo and Arguden, 1991). However, 60 mm/hour is beyond any of the rainfall intensities that were required to trigger the 14 debris flows studied by Rodolfo and Arguden (1991). More importantly, the 10 mm/10 min represents the short-term intensity (most intense ten minutes), not the average intensity over the entire triggering rainfall that is generally applied in rainfall threshold analyses (e.g. Caine, 1980; Guzzetti et al., 2008). As such, the 10 mm/

10min does not equate to an average triggering rainfall intensity of 60 mm/hour. It is therefore perhaps an overestimation of the rainfall intensity required to trigger lahar at Mayon. In order to understand the derivation of this threshold, and more importantly, why 40-45 mm/hour is a suitable threshold for evacuation, it is necessary to compare this critical threshold with the available rainfall and lahar data.

**Analysis of the rainfall threshold**

Ideally a triggering rainfall event should be described by its duration (D) and amount of precipitation (E), which can be used to calculate intensity (I) (Berti et al., 2012). The greatest uncertainty in these types of analysis is owing to the difficulty of identifying the start of the triggering rainfall and the timing of the landslide (the end of the triggering rainfall; Brunetti et al., 2010).

No readily accessible detailed historical database of modern lahar events for Mayon exists, so one had to be assimilated from the available reports, interviews and the published literature (Appendix I). In order to compare lahars with rainfall, only events that were described as occurring on a particular day (rather than over a period of several days) could be included in the analysis. The recorded events were constrained to the 34-year period of available rainfall data from 1978 to August 2012 (Chapter 5). Of the 46 events in Appendix I, only four of the records (including the Reming event) include times of lahar initiation and two of these timings appear not to correspond with the recorded rainfall. The record contains eruption and post-eruption lahars, of which 11 were described as being triggered by typhoons. For the purpose of this analysis, it was not possible to compare the local government's rainfall intensity with the entire 34-year rainfall record as the completeness of the lahar record could not be verified. Lastly, there is little information available to categorise the lahars based on their size, therefore it is not possible to differentiate them by size.

A second limitation is the resolution and suitability of the rainfall data. The available rainfall data is recorded over 6 hour intervals so it is not possible to determine peak hourly rainfalls. The PAGASA rain gauge at Legazpi City airport is the closest to Mayon volcano and sits at a height of 18 metres above sea level. Rodolfo and Arguden (1991) found that rainfall falling on the volcano (Bonga and Basud pyroclastic fans, 600m above sea level) can be significantly higher than the rainfall falling on Legazpi City during the same event (see Figure 8.7).

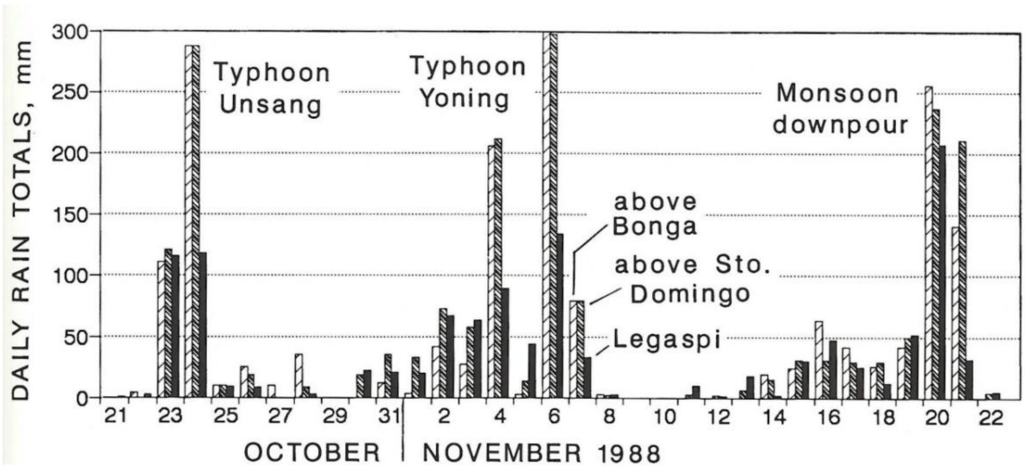


Figure 8.7 Total daily rainfall above the apex of the Bonga Fan, on the Basud Fan above Santo Domingo (both 600m above sea level), and at Legazpi airport (18 above sea level), from October 22 to November 22, 1988. Source: Rodolfo and Arguden (1991: fig. 3: 75).

The difference in rainfall prompted the local government to install a number of rain gauges within communities on the volcano:

> *'…it would be advisable for us to install it upslope of the volcano because their situation that it's raining heavy in Mayon area; here is very sunny. So from there we can already get the amount of rainfall and we can have an estimate as to the water that will come down from the slope.'* (LG Disaster Manager 3)

The programme of installation began in 2010 and these rain gauges present an opportunity for community-based monitoring and warning. LG Disaster Manager 2 said they teach communities how to use the rainfall threshold, who then record hourly rainfall except during *‘normal periods’*[5]. As such, the record is not continuous but it is implied that the periods when no rainfall was recorded represent the occurrence of insignificant or no rainfall. The records are then transmitted to the local government, where they are combined with data from PAGASA for a more comprehensive analysis:

> *‘We train them, some of the barangay captains, barangay…on how to read record of rain gauge and...when they send us their reading we compare it with the reading of the PAGASA and, from there, we come into a decision, so once we have a decision we communicate and once we communicated it to the community then they are the one who will mobilise for evacuation’* (LG Disaster Manager 3)

Although the procedure for issuing a warning remains (quite) centralised, the communities are more informed about what volumes of rainfall might trigger lahar and the, in part, implementation of one of the recommendations after Reming, which was to establish community-based warnings (Chapter 7). Unfortunately, data from the local rain gauges were not available for application to this work.

Before carrying out the rainfall threshold analysis, it is necessary to explain the definitions adopted and the assumptions that were made. Rodolfo and Arguden (1991) defined triggering rainfall as a ‘rainfall event that includes no pauses longer than an hour…[and] only refers to the accumulation and time elapsed up until a flow starts’ (Rodolfo and Arguden, 1991: 75). This definition is similar to that for the ‘cumulative rainfall’, which is measured from the beginning of the rainfall event to the time of failure (Berti et al., 2012). The critical ‘accumulation’ rainfall (150 mm) being utilised by the local government is thus inferred to equate to the ‘triggering rainfall’ or ‘cumulative rainfall’ defined here. Without knowing the time of failure, however, it is impossible to determine the accumulated rainfall volume and hence to determine the average intensity of the triggering rainfall. Because of these problems and given the fact that the 60 mm/hour threshold appears to be derived from Rodolfo and Arguden’s (1991) measure

[55] LG Disaster Manager 2

of the most intense rainfall, the decision was made to focus on the rainfall thresholds over much shorter recording intervals.

Rainfall intensity was calculated from the average hourly rate of rainfall over the peak six hour rainfall recorded for each of the 46 lahar events in Appendix I. These intensities of rainfall were plotted alongside the hourly rainfall intensity calculated from the peak 12 hour rainfall for the same 46 events, as well as over the 24-hour period on the date the lahar(s) occurred (see rainfall data in Appendix I). These data points are presented in Figure 8.8. The graph compares the data with the minimum and maximum evacuation threshold along with equation (5) from Rodolfo and Arguden's (1991) analysis. Lahars that occurred during and after eruptions are differentiated, with a distinction made between post-eruption lahars less than one year after an eruption (i.e. those that occurred on any date following the end of the previous eruption up until one year) and those that occurred over a year since the last eruption. The low rainfall intensities recorded during eruption lahars reflect very localised heavy rainfall owing to eruption updrafts of moist surface air that condense to form rainfall (Rodolfo, 1989), which may not have been recorded at the PAGASA rain gauge. The low intensities of rainfall required to trigger post-eruption lahars that have occurred less than one year since the last eruption are assumed to be owing to the availability of loose, unconsolidated volcanic material from the recent eruption.

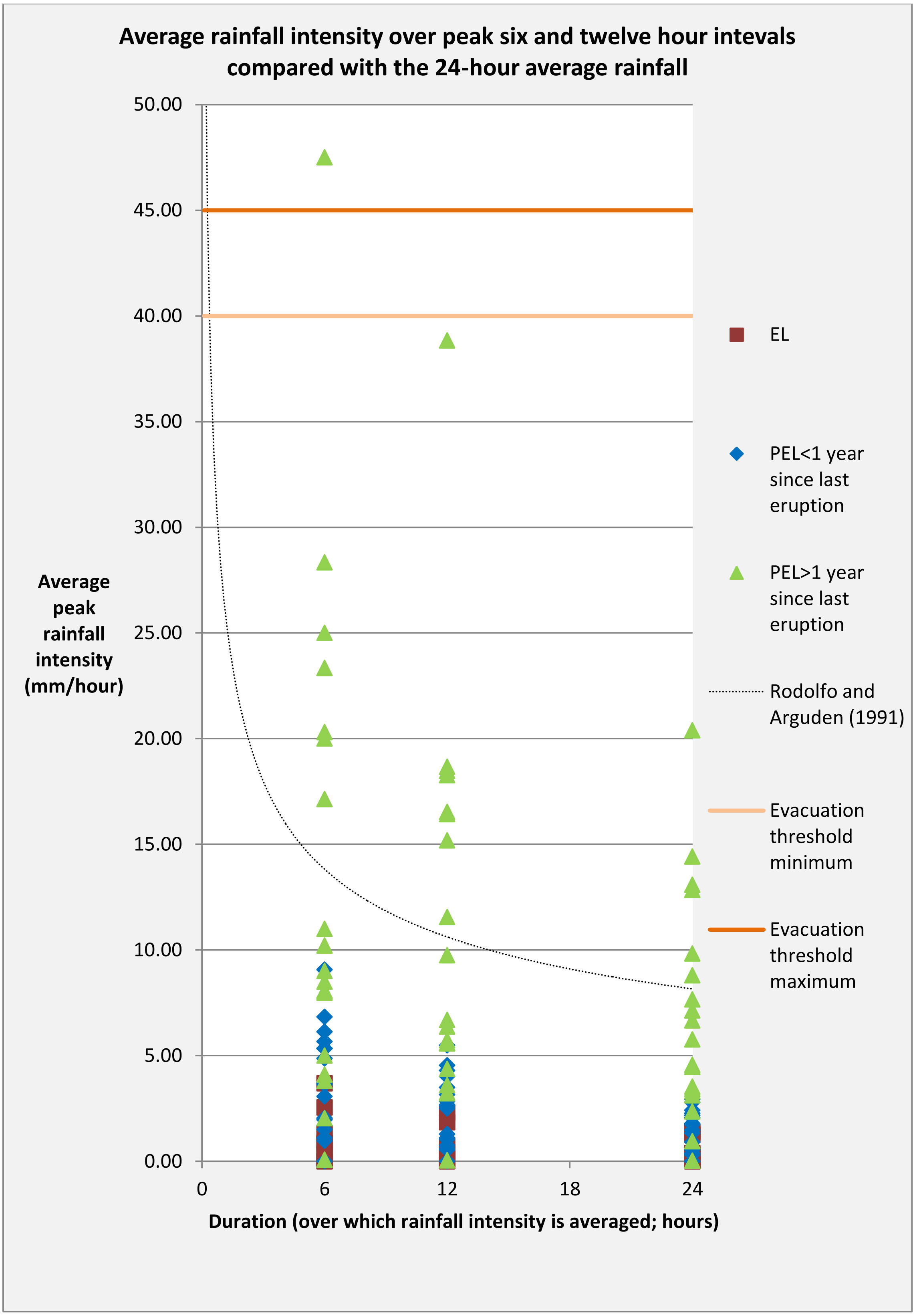


Figure 8.8 Rainfall intensities for eruption lahars (EL) and post-eruption lahars (PEL) occurring either less than or more than one year since the last significant eruption. The data represent the rainfall intensities for each of the 46 events are calculated over their 6, 12 and 24 hour rainfall durations. Source of rainfall data: (PAGASA, 2012); source of eruption information: PHIVOLCS (2012).

The events triggered by the highest intensities of rainfall all occurred more than a year after the last eruption. However the lahars that occurred more than a year after the last eruption were also observed to be triggered by rainfall intensities recorded as low as 2 mm/hour (discounting the one event which apparently coincided with no recorded rainfall and is therefore assumed to be erroneous) and as high as 47.5 mm/hour. There appears, therefore, to be no obvious relationship between the average rainfall intensity and lahars triggered more than a year since the last eruption. The existence of ten of these events below Rodolfo and Arguden's (1991) correlation suggests that their threshold does not apply to every post-eruption event.

The 60 mm/hour threshold for lahar triggering surpasses all of the rainfall intensities calculated for the 46 lahar events, including the one that occurred after Reming (during Tropical Storm Juaning, 2011). Furthermore, only the Reming rainfall intensity crossed the minimum threshold for evacuation. The key finding from the rainfall intensity analysis is that rainfall intensity measured over a constant duration differs between lahar events, thus questioning the applicability of a single threshold for lahar initiation. Furthermore, there is also the concern that the 60 mm/hour rainfall threshold misrepresents the study by Rodolfo and Arguden (1991) since the assumption is made that their criteria of 10 mm or more rainfall falling in the most intense 10 minutes can be scaled up to 60 mm/hour (as mentioned earlier).

One reason for this discrepancy could be that the 60 mm/hour only applies to the triggering of large lahars. LG Disaster Manager 2 said that 100 mm/hour fell during Reming, however this cannot be verified with the data available. Furthermore, it is ambiguous whether the 60 mm/hour rainfall intensity reflects the anticipation of large lahars. LG Disaster Manager 2 implied during an interview that this rainfall would bring about '*destructive lahar'*, but in follow up correspondence they suggested that 60 mm/hour represents *'the start of small lahar and if rainfall increases lahar becomes more destructive*.' This interviewee clarified that *'small* *lahars are just confined along the river channels, non-destructive'* (LG Disaster Manager 2, email correspondence, 3rd March to 7th March 2014). Furthermore, during an interview in October (2012), the interviewee described the 68 mm/hour rainfall at the threshold for a destructive lahars. Rodolfo and Arguden (1991) defined lahar triggering rainfall as rainfall that results in a **'**flow of water and debris in any proportion, of any magnitude and duration**,** in Basud or Mabinit' (Rodolfo and Arguden, 1991: 75). This suggests that warnings based upon their study give no indication of the magnitude (and duration) of the lahar, and that this threshold only relates to the Basud and Mabinit channels, which produced very small lahars during Reming (Paguican et al., 2009). As the 60 mm/hour threshold appears to be based on this study, the assumption is that it is designed to reflect the initiation of lahars of any magnitude (i.e. small or large) that occur at Mayon.

A second reason for the observed variability of the rainfall intensities could be due to the influence of the last eruption. According to LG Disaster Manager 2, the critical rainfall intensity threshold of 60 mm/hour should be adjusted based upon the time since the last eruption:

> *'…it's only a matter of changing the warning criteria - if after eruption maybe evacuation procedure will be done at maybe 40 mm*[/hour] *of rainfall but without fresh eruption will go back to the criteria that we evacuate for lahar at 60 mm/hour because…the threshold of lahar will be at 60 mm/hour.'* (LG Disaster Manager 2)

The above quotation suggests that the 60 mm/hour is designed for post-eruption lahars, which was also mentioned by PHIVOLCS Geologist 3 (*'somewhere between post-eruption to non-eruption lahars'*), although they did not clarify at what point lahars become 'non-eruption'. Although these statements provide a reason for why the 60 mm/hour threshold far exceeds the rainfall intensities for eruption lahars and post-eruption lahars that occurred within twelve months of the last eruption (Figure 8.8), these two statements also imply that experience, judgement (and perhaps guesswork) are used to adjust the rainfall threshold.

In order to explore the reliability of these judgements, Figure 8.9 presents a chronology of the rainfall intensities of the lahar events and eruption volumes over the 34 year period. This chronology includes six eruptions: 1978, 1984, 1993, 1999, 2001 (two events) and 2009 (see Appendix F). The 2006 eruption is not included owing to its insignificant contribution to available source material (see Chapter 7). There are two scales on the x-axis: on the left is rainfall intensity and on the right is the volume of material erupted (in million cubic metres). The limitations of this analysis include the fact that the figure of volume of material erupted includes tephra, pyroclastic flow and lava flow and so does not reflect the precise volume of material available for lahar entrainment. The total volume of ejecta had to be utilised since it was the only consistently recorded volume for each of the eruptions, however Table 8.1 gives some indication of which were the more explosive (rather than effusive) eruptions. Lastly, the rate at which this material is depleted over time is also unknown.

Table 8.1 Volume of volcanic material erupted over the 34-year period. Source: PHIVOLCS (2011c).

| Year of eruption | Total volume of erupted material (million $m^3$) | Pyroclastic flow (million $m^3$) | Lava flow (million $m^3$) | Tephra fall (million $m^3$) |
|---|---|---|---|---|
| 1978 | 20 | *** | *** | *** |
| 1984 | 70 | *** | *** | *** |
| 1993 | 50 | 5 | 45 | undetermined |
| 2000 | 28.6 | 13.91 | 11.95 | 2.69 |
| Jun-01 | 15.5 | 7.29 | 7.62 | 0.57 |
| Jul-01 | 10.2 | 5.49 | 3.8 | 0.87 |
| Jul-Oct 2006 | 80 | *** | ~80 | minimal ash |
| Jul-Dec 2009 | 37.1 | *** | ~37 | minimal ash |

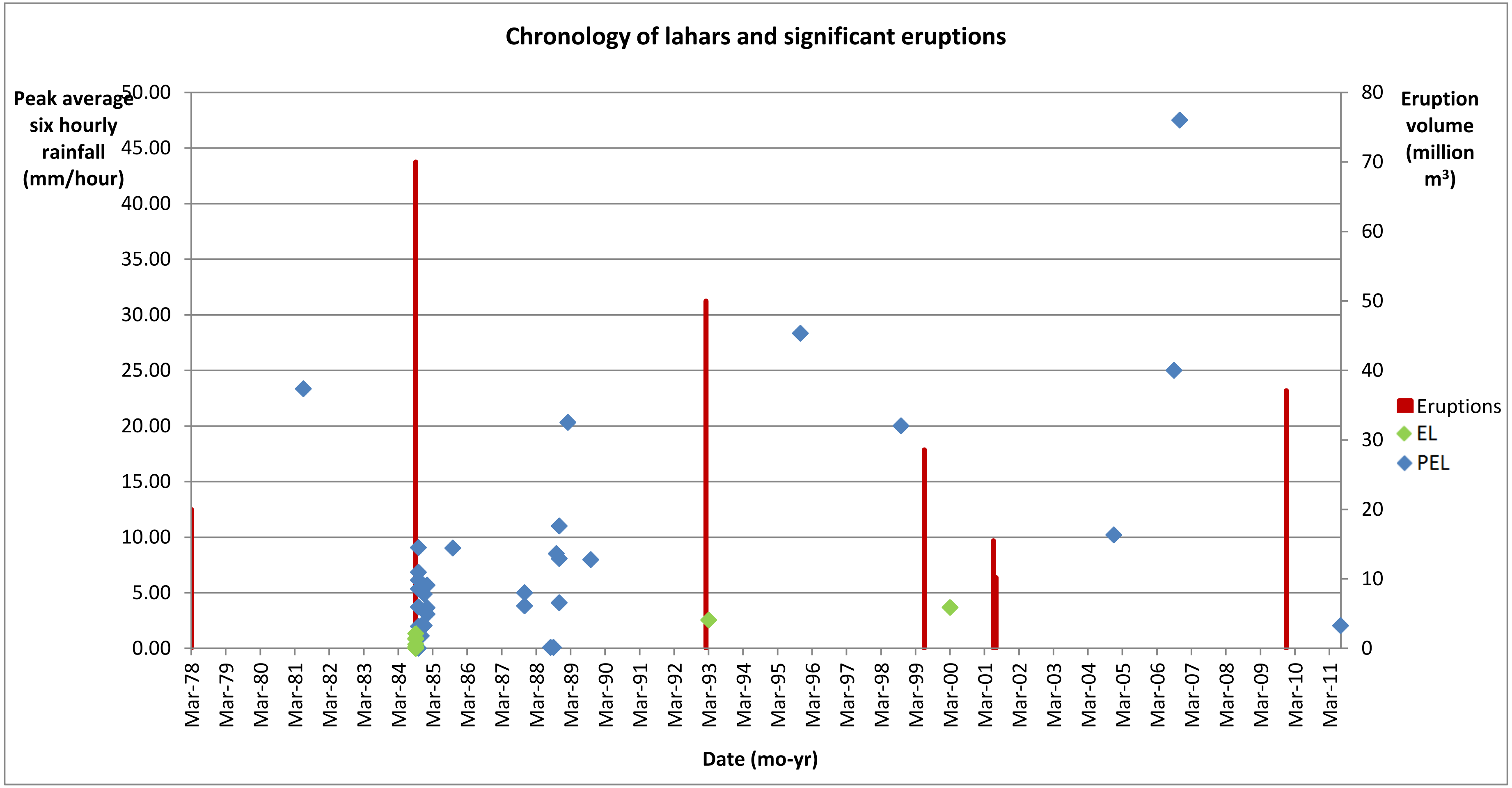


Figure 8.9 Chronology of the peak average rainfall intensity of eruption lahars (EL) and post-eruption lahars (PEL) events and the occurrence eruptions and their volumes of ejecta over the 34 year study period. Source of rainfall data: PAGASA (2012); source of eruption data: PHIVOLCS (2012).

In spite of the limits of the data, Figure 8.9 shows no strong correlation between rainfall intensity and the time since the last eruption. It is observed that lahar events that were triggered by particularly intense rainfall tended to occur at least a couple of years after the last eruption. There is a concentration of events following the 1984 eruption (the largest over the 34 year period) but this might partly be a consequence of the many in-depth studies of lahars were conducted over this time. In spite limitations, the results suggest that adjusting the threshold over time is largely down to guess work or is perhaps, in fact, inappropriate and that more data are required to refine how this threshold should be adjusted. Given the range of rainfall intensities presented in Figure 8.8, in particular those lahars that occurred more than a year after the last eruption, it is questionable whether it is possible to implement a rainfall threshold for warning for lahars. There are also other factors that might influence the rainfall threshold. In a study of debris flows in Taiwan, it was found that the rainfall intensity-duration threshold for debris flow initiation reduced after the 1999 earthquake (ML 7.13) loosened material on slopes (Jan and Chen, 2005). Albay is seismically active, thus the influence of this hazard should be a consideration. In the context of typhoons, some scientists and local government interviewees indicated that it was because the rainfall was associated with a typhoon that it was intense enough to trigger the lahar (see Chapter 7). Eleven of the 46 lahar events in Appendix I are believed to have been triggered by typhoons, although there is uncertainty as to whether the 1981 event was triggered by a typhoon or tropical storm.

Two of typhoons (Milenyo and Reming) brought the highest recorded intensities of rainfall and the two most deadly events (the 1981 lahars, which killed 40 people, and Reming) were both post-eruptive and triggered by typhoons (or in the case of the 1981 event possibly a tropical storm). It is difficult to evaluate in detail the significance of typhoon associated rainfall owing to the small number of records and the need for an analysis of all typhoons that have occurred over this period, as well as information on the magnitude and destructiveness of the lahars produced.

The discrepancies in the lahar records and the thresholds for evacuation and lahar initiation outlined in the analysis above could reflect the problems with the data. The rainfall intensities that were calculated for this analysis represent an average of rainfall recorded over six hours, so this averaging may underestimate the peak occurrences of rainfall. Furthermore, the government's 60 mm/hour threshold may be utilised because it better reflects the intensity of rainfall that triggers lahars on the slopes of the volcano, compared with data used here from the PAGASA rainfall records collected at Legazpi City airport. Only the PAGASA records were available for analysis and so a comparison of the data with that being recorded on the slopes of Mayon is a goal for future research. At the same time, however, the rain gauges established by the local government have only been in operation from 2010 and, therefore, represent only a short-period of monitoring. It is recommended that the local government's barangay monitoring of rainfall be expanded and designed to ensure periodic measurements of rainfall to improve the baseline of representative rainfall data. Furthermore, monitoring by local communities of small lahars could enhance future records. The limits of this analysis are mentioned for transparency and to highlight the difficulty of deriving these thresholds. However, these limitations should not understate the findings from the analysis of the critical rainfall intensity, which has highlighted some limitations in this approach and important considerations for decision-makers.

**Limitations of the rainfall threshold utilised at Mayon**

Rodolfo and Arguden (1991) suggest limitations of their analysis, including the fact that it is based on only 16 debris flow events. Furthermore, their study focused on two channels (Mabinit and Basud) that are now no longer a major source of lahar. PHIVOLCS Geologist 3 argued that specific thresholds are required for each channel owing to the different distribution of pyroclastic material, however further studies are required to verify this. If this is the case and, moreover, given the fact that the rainfall threshold for lahar initiation appears to vary between events (Figure 8.8), decision-makers (be it local government or NGOs) need to be aware that the threshold cannot be universally applied. Academic Geologist 1 said that, from her experience in other mass movement prone areas, NGOs tend to apply the same threshold to wide areas. This situation emphasises the importance of the community-based warning system and consideration of the local environmental processes and the influences of upstream rainfall. Such systems can only be successful through good communication of the underlying science behind the warning:

> *'they* [Mayon residents] *broadly know that if there's a really heavy rain there is a chance of having a lahar. But they don't know anything about the threshold. They're really relying on people like, you know, the weather bureau and* [APSEMO] *to come and tell them when to get out.'* (International Volcanologist)

LG Disaster Manager 2 stated that they have explained the threshold to some Barangay Captains, but the process of decision-making is still centralised. LG Disaster Manager 2 said that Barangay Officials have to provide the local government with the threshold figure, who then decide whether to issue a warning or an evacuation order[6].

***The need to anticipate magnitude***

The Reming lahars case study emphasised that it is the anticipation of destructive lahars that is of greatest concern to communities and emergency responders[7]. For example, the Executive Director of Local NGO B felt that the government scientists should have predicted the volume of lahar based on the rainfall forecast for Reming (see Chapter 7). However, the ambiguity regarding the magnitude of lahars that will be triggered by certain rainfall intensities implies that it is not possible to provide this level of 'prediction' to communities. This emphasises a need to manage expectations of what science can offer, but also consider how to strengthen the anticipatory components of lahar hazard analysis.

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[6] LG Disaster Manager 2

[7] PHIVOLCS Volcanologist, Local NGOs A and B and National NGO are particularly concerned with the volume of material available for entrainment.

Accounting for debris-flow volume necessitates determining the volume of initiation failure or failures, as well as the material that is entrained and lost as the lahar travels (Jakob, 2005). Such data are rarely available before a lahar is triggered. PHIVOLCS Volcanologist 1 said that they give advance information to the local government regarding the availability of volcanic material that might lead to lahars; however Figure 8.9 indicates that there is not a clear correlation between the size of the last eruption and rainfall intensity. However, it might be possible to quantify potential lahar volume in terms of triggering parameters if the database of lahars created in this study is augmented with continuous studies of rainfall and lahar events to determine critical thresholds for different magnitudes of events. For instance, somewhere between the rainfall that fell during Milenyo and the rainfall that fell during Reming is a critical threshold where lahars not only occur, but do so at a catastrophic scale.

***The short-term (reactive) approach***

Reliance upon real-time monitoring of typhoon rainfall is a short-term approach to anticipating lahar occurrence. Whilst the early warning system is necessary (owing to the fact that communities still reside or return to work in high hazard zones), probabilistic analysis of longer term risk, especially that which is linked to occurrence and severity (see Jakob, 2005), might help with long-term planning.

The recurrence interval of the triggering rainfall intensity has been suggested as a means of estimating the long-term probability of landslide and debris flow occurrence (e.g. Hincks et al., 2013), however this assumes that the threshold rainfall intensity is (1) constant and (2) will always trigger an event, which is not the case at Mayon. Furthermore, the typhoon Reming case study demonstrated that it is necessary to look beyond the recurrence interval of rainfall intensity and consider what phenomenon might bring this rainfall, for example a supertyphoon. As such, critical rainfall thresholds should be accompanied with scenario-planning, which might only be possible through expert judgement (e.g. Lacasse et al. 2008).

**Summary of critical rainfall thresholds for anticipating lahar occurrence**

Whilst the rainfall threshold being utilised does not apply to all events, it was successfully implemented during the recent Typhoon Yolanda (Haiyan, November 2013):

> *'Albay was only affected by more than 100 kph wind and rainfall of an average of 29 mm per hour so we did not evacuate people from Mayon Volcano as it did not reach the threshold. Our evacuation was related to coastal flooding, wind, flood and landslides then not much on mudflow.'* (LG Disaster Manager 2, email correspondence 5th December 2013)

Furthermore, at the time of interview, several government scientists stated that (through collaboration with Japan Aerospace Exploration Agency, JAXA) a thorough analysis of critical rainfall thresholds at Mayon was soon to commence.

There were, however, a number of points raised in the above analysis that are of concern. The thresholds for lahar occurrence and evacuation are much higher than the rainfall hypothesised to have triggered any of the 46 lahars analysed in this study. This reflects either a misinterpretation of Rodolfo and Arguden's (1991) work or the limits of the lahar and rainfall data analysed in this chapter. There is no strong correlation between the time since the last eruption and the intensity of triggering rainfall. However, the different rainfall triggering thresholds for the 46 lahar events emphasises how lahar hazard changes over space and time at Mayon volcano. Decision-makers need to be aware that the rainfall threshold has to be updated to reflect changes in conditions of susceptibility, but that it might not be possible to anticipate the degree to which the threshold will change. Seeing as both the local government and scientists appear to rely on experience and their own judgement to make these adjustments, it is essential for NGOs to engage with them directly.

Given the differences in rainfall between the PAGASA rain gauge and that recorded on the slopes, there is clear justification for a local level approach, which should be decentralised in order to give autonomy of warning and evacuation to local communities. Community-based monitoring and observation of lahars could help to enhance lahar databases, especially with regard to their timing and approximate size. There is also a need to estimate the potential volume of lahar (even qualitatively) that might be triggered based on, for example, different thresholds of rainfall. The data limitations observed within this analysis emphasise why the associated uncertainty with critical rainfall intensity thresholds needs to be well communicated to, for example, NGOs who might be considering implementing this approach.

Finally, the approach focuses on anticipation in the short-term, which is necessary for the evacuation of those still residing in high risk areas. However, probabilistic, long-term approaches should be explored – especially those anticipating whether rainfall might occur in close proximity to large volcanic eruptions. Given the problems with regard to data in the context of this analysis, it may be more likely that a scenario based approach is adopted. Preparedness and mitigation strategies need to be informed by scenarios of lahar inundation accompanied by other hazards (e.g. typhoons).

### 8.1.4 Anticipating multi-hazard lahar disasters: the role of scenario planning

It has been suggested that during quiescent periods, scientists should undertake (1) the analysis of individual scenarios and (2) consider a range of possible hazard events with their probabilities of occurrence (Hill et al., 2013). Although the scientists, local government and NGOs (and some communities) might have expected the Typhoon Reming lahars, the magnitude of these was generally unexpected. As such, anticipating the likelihood of scenarios similar to or more extreme than the Reming lahars is a necessary means of bolstering the multi-hazard approaches being adopted in the province:

> *'although the main hazard is typhoon the secondary hazard could be flooding, we have the debris flow from Mayon so it's sort of multi-hazard. Of course, complex scenario it is not far-fetched that we can experience a strong or super typhoon whilst Mayon*

> *volcano is erupting - that's not impossible - it could happen anytime'* (LG Disaster Manager 3)

The above interviewee said that, in light of this situation occurring, they had developed contingency planning based on the 'worst-case scenario', although the details of this are not available for this study. PHIVOLCS Geologist 1 and 2 also referred to the modelling of Typhoon Reming in the lahar hazard map as '*a worst-case scenario.*' Similarly, one NGO interviewee[8] noted that the local government's '*worst-case scenario*' planning prior to Reming did not account for an event on the scale of Reming. These assertions indicate a scenario based approach to anticipating lahar disasters that relies on worst-case scenario planning and also that this approach essentially failed as Reming was not anticipated. The choice of labelling the scenario as 'worst' implicitly defines the acceptable risk that is beyond the capabilities of scientists (Marzocchi et al., 2012b).

Given that many changes in the revised (2011) lahar hazard map (Figure 8.2) generally reflect the spatial extent of the Reming lahars, it questionable whether scenarios of greater impact than Reming have been considered. Two PHIVOLCS scientists did emphasise that PAGASA defined the flooding from Typhoon Reming as a 1 in 40 year flood (PHIVOLCS, 2006a), with one noting that Reming did not occur close to a significant, recent eruption:

> *'...if we had that* [Reming] *kind of rainfall after the eruption* [2000-2001] *then we would have seen really massive lahars.'* (PHIVOLCS geologist 3)

Anticipating the impact of this type of event relies on both long- and short-term anticipation. Planning scenarios in advance and then updating them as real-time information becomes available, for example the volume of recently erupted material and the intensity of the typhoon and associated rainfall, requires some initial statistical analysis of the likelihood of occurrence of this type of event. In recent years, the philsophy underpinning risk assessments across a number of fields, including volcanology, landslide and earthquake, has moved from

[8] DRR Point Person (Local NGO A)

reliance on conceptualisation and deterministic evaluations to probabilistic assessment and modelling in order to characterise intrinsic uncertainties (Martí et al., 2008; Neri et al., 2008; Hincks et al., 2013). At the same time, however, probabilities are not always understood by decision-makers (Martí et al., 2008; Solana et al., 2008). In preparing for a Reming-style event, the local government are apparently more concerned with typhoon hazard in the short-term:

> *'Actually we don't have a problem about the probability of occurring because we have the forecast information. So our preparation is not only typhoon. Even preparing for Tropical Convergence Zone, cold front, active low pressure area, tropical depression, tropical storm – they have rain with similar impact* [as] *typhoon.*' (LG Disaster Manager 2)

This implies a predominantly reactive strategy to lahar risk reduction. However, their approach does acknowledge the range of hazards that might affect communities within a single event:

> *'Actually our plan is scenario based but hazard is specific because for areas around Mayon volcano that must be a different scenario. For coastal, it must be different one although we're talking about the same hazard (the same typhoon) so it must be hazard specific'* (LG Disaster Manager 2)

Identifying and quantifying scenarios for multi-hazards is reliant on the availability of data and the resources and knowledge available to determine these. However, given the multi-hazard exposure of the province, including the frequent occurrence of typhoons and the observed cycles of eruptions (Punongbayan, 1985) it is necessary to ensure that the scenario plan has considered alternative scenarios in so far as possible. Clear communication of the uncertainty surrounding these scenarios is also essential.

The fact that elements of the hazard map and rainfall thresholds rely upon expert judgement and experience means that engagement with these experts is an essential means of truly understanding, within the limits of uncertainty, the lahar hazard at Mayon. The following discussion briefly explores the extent and barriers to this type of engagement, drawing upon the interviews with NGOs and scientists (government and academic) conducted in the Philippines from October-November 2012.

## 8.2 Engagement between scientists and NGOs: capacity, trust and contention

As part of the October-November 2012 visit to the Philippines, six NGO representatives and ten scientists were asked, or brought it up themselves, whether they have worked with scientists or NGOs respectively. The views reflect experiences from Albay and beyond and so the analysis of these experiences helps to build on the general discussion of engagement between NGOs and scientists initiated in Chapters 4 and 5.

Government and academic scientists appeared to recognise the need for engagement at the local scale. This was acknowledged by one NGO interviewee[9] who stated that both academic and government scientific groups are increasingly willing to share their information with communities, but there is a need to facilitate the engagement between scientists and communities. Indeed, the process of engaging with communities and NGOs is apparently in one direction, with the scientists sharing information but viewing it as their, not the communities', role to assess hazards:

> [Referring to the EngD research] *'But methods for scientific multi-hazard assessment will not be done the community, right?'* (PHIVOLCS Geologist 1)

The PHIVOLCS (and other government) scientists channel their communications through government structures, for example IECs with the local government (see Chapter 7). However, PHIVOLCS Geologist 1 implied that sustaining the adoption of science might be more achievable through direct engagement with communities rather than local government, owing to staff turnover of the latter at the end of each electoral term:

[9] Deputy Executive Director (National NGO)

> *'…the community based early warning system that we generated for tsunami related to that event we seen that there are a lot of Barangay Captains and local Mayors who were already changed and so the information stopped…but the community early based warning system…that pilot community reacted properly as far as the earthquake was concerned'* (PHIVOLCS Geologist 1)

Furthermore, three scientists[10] did identify NGOs as opportunities for engaging with communities and sustaining the impact of their science, and two of these interviewees respectively noted that this is because NGOs have good links with and are trusted by the community. PHIVOLCS Volcanologist 2 perceived NGOs as filling a gap in the limited reach of scientific agencies:

> *Government and NGOs have increasingly realised that they need one another – for PHIVOLCS/government, it's about how to convince NGOs that we have information – we have to advertise.* (International Volcanologist 2)

Above all other concerns NGO interviewees emphasised that the information will only be utilised if it is made understandable[11] and accessible to those who need it[12] (*cf.* Basher, 2013). Two NGO representatives felt that the available science is not at an appropriate scale[13], others felt that it was expensive to access[14] and another pointed out that scientific research tends to be conducted in the same areas[15]. This last point emphasises the need for communication and collaboration between NGOs and scientists, since NGOs might be able to advertise to scientists where the greatest need is. However, the interviews demonstrated that scientists are also constrained in their ability and willingness to assist.

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[10] Academic Geologist 1; PHIVOLCS Volcanologists 1 and 2
[11] DRR Specialist (INGO A); Executive Director (Local NGO B); DRR Point Person (Local NGO A); Humanitarian Programme Coordinator (INGO B)
[12] International Volcanologist 1
[13] DRR Specialist (INGO A); Humanitarian Programme Coordinator (INGO B);
[14] Executive Director (Local NGO B) DRR Specialist (INGO A); Humanitarian Programme Coordinator (International NGO B)
[15] DRR Country Programme Advisor (International NGO A)

### 8.2.1 Access to scientists and availability of information

There appears to be a lack of guidance regarding, in particular, how engagements between government scientists and NGOs should be managed. PHIVOLCS Volcanologist 2 suggested that NGOs rely upon community experiences for hazard mapping because they do not approach scientists or because the hazard map is not available. However, as noted above, several interviewees commented upon varying experiences of being charged for government science across different agencies. One scientist said that PHIVOLCS will provide (within limits) a free service[16] and another[17] said they can provide data to those NGOs who are not able to fund PHIVOLCS to conduct the analysis. The Executive Director of Local NGO B recalled being charged by PAGASA for basic data, which surprised the interviewee, whilst being given electronic geohazard maps for free from the MGB[18]. Justifying this cost to management was noted by one interviewee as a major blockade to engage civil society with science more widely[19]. Another NGO representative said that the local government will provide them science for free because *'they know we are church'*[20].

As highlighted in Chapter 5, informal partnerships often form the basis of engagement between scientists and NGOs, particularly when funds are not available:

> *'Well we try to access materials from Manila Observatory, for example, for free…This is the informal partnership that happens except that, again, if you look at scale, that's national scale and not really municipal or even barangay scale.'* (Humanitarian Programme Coordinator, International NGO B)

However, this quotation indicates that these free materials may not be applicable to community-based DRR and the information that NGOs require might necessitate funding (e.g. the MO-UPNIGS, 2009, maps). Examples of informal access to science through family

[16] PHIVOLCS Volcanologist 1
[17] PHIVOLCS Geologist 1
[18] The member of staff from Local NGO B said the geohazard maps are too expensive.
[19] DRR Specialist (INGO A)
[20] Researcher (Local NGO C)

members[21], former colleagues[22] and well established relationships with individuals within agencies were presented[23]. However, without institutional partnership, the sustainability of these engagements depends upon personal contacts, and if these are lost then the engagement may also be ended:

> *'You know these people who died in the helicopter crash from PHIVOLCS? We had a lot of tie up with NGOs through them…'* (PHIVOLCS Geologist 3)

Limited capacity within government institutions was identified by NGOs as a key difficulty in accessing science and scientists. Likewise, four scientists and one local government interviewee[24] noted the inadequate coverage and systems in place for the purpose of gathering data and monitoring of hazards across the Philippines, the consequence of which was noted by one NGO representative:

> *'those rain gauges, those early warning systems* [were] *either stolen or ..not maintained. The maps were not updated … it's because there was only one …old man who works for PAGASA and …he said…: "I couldn't possibly look after all of that – I couldn't possibly accomplish updating the maps and everything." … it really becomes a challenge when you go down…to the local government units because they don't have enough resources to maintain and to keep things updated.'* (Humanitarian Programme Coordinator, International NGO B)

Despite high capacity and political will in Albay, resources are still an issue for government scientists; for example, the local government have had to augment the PAGASA rain gauge network with their own system. International and national investment in volcanic monitoring in the province has proven to have generated trust between NGOs and the scientists. After the 1993 eruption (which killed 77 people), PHIVOLCS Volcanologist 1 did a lot to restore faith amongst the community, which was reflected in one local NGOs description of him:

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[21] LG Disaster Manager 1's son produced hazard maps for the municipality.
[22] LG Disaster Manager 2 used to be the head of Local NGO C
[23] Local NGO B referred to PHIVOLCS Volcanologist 1 by his first name and imply that they will just ask him whenever they need information
[24] International Volcanologist; PHIVOLCS Volcanologist 1; PHIVOLCS Geologist 3; MGB National Geologist; LG Disaster Manager 2

*'the resident volcanologist, very kind…man, so we make use of their data. It's really helpful and it's technical…it's understandable…it's just that we cannot give it directly to the community.'* (Executive Director – Local NGO B)

This quotation also implies that the success of their engagement with this scientist is owing to his ability to communicate the science, at least in a manner that is meaningful to the NGO. Limited capacity and resources were not unique to the local level; PHIVOLCS national level scientists highlighted times when they had lost key personnel through tragedy on the job[25]. MGB Regional Geologist noted the lure of more profitable endeavours abroad, illustrating the fragility of the scientific population within the government (and academic) sectors:

*'we had problems with people – we lost a lot of geologists who transferred to exploration companies – so only three of us were left out of, I think, eleven geologists - only three were left to do the work.'* (MGB Regional Geologist)

The creation and maintenance of scientific knowledge is a big problem for the Philippines (see Rodolfo, 1995), and undoubtedly in similar or lower income countries. Given the limited capacity and resources of the government scientists, NGOs have tried to access information from other sources, for example academia. As indicated in Section 7.1, there are numerous power struggles related to the source of the science that is utilised.

### 8.2.2 Sourcing science: overlapping mandates and turf wars

In spite of a recent joint university and government real-time weather warning project – National Assessment of Hazards, NOAH – described by Academic Geologist 2, engagement between government and academic scientists has historically been contentious. There appears to be a mutual sense of frustration between academics and government agencies; several examples from PHIVOLCS were shared regarding irresponsible mapping[26] and hazard analysis[27] undertaken by academics, as well as their being beaten to publishing and being

[25] PHIVOLCS Geologist 1
[26] PHIVOLCS Volcanologist 2
[27] PHIVOLCS Geologist 1

unhappy with what the academics published[28]. In the defence of academics, Academic Geologist 1 stated that they are under pressure to produce papers and this interviewee could not understand why there is so much tension between academic and government scientists since they face similar problems:

> *The links between government, academia, and the private sector are not strong/good. The reason being the different mandates and turfing/stepping on toes – don't really know why this is the case since we have such few workers; competition; jealously. Also,* [it is] *a problem of* [lack of] *time.* (Academic Geologist 1)

NGOs thus have the difficult task of accessing the data, information and expertise they need, without becoming embroiled in these politics. There was an apparent sense amongst the government agencies that it is their mandate[29] and, therefore, responsibility to produce and disseminate the science[30]. But given the fact that the government scientists (and local government) are resource constrained, one practitioner questioned whether the work of government scientists is always credible:

> *'The scientists working in the government, there are only a few of them. …And they are also tasked with many things and they cannot just cover a lot of our higher risk areas… even when they did the assessment in St Bernard, there were a lot of questions. How come were they able to come up with these high risk areas, moderate risk areas when they were there only for a few days? …So this is why MO, UPNIGS and other scientists – we must make a way for them to be able to reach those high risk areas.'* (DRR Specialist, International NGO A)

What the last quotation emphasises is the role of NGOs in enabling these scientists to reach the areas where need is greatest. The concerns of the last interviewee were also supported by Academic Geologist 1's unease regarding the fact that (reflecting on MGB maps) the government maps are not peer-reviewed and that the invitation to review these maps is more a validation exercise based on the presence of academics at these events, rather than them being able to critically evaluate the maps.

[28] PHIVOLCS Geologist 3 (this particularly relates to Reming)
[29] Executive Director (Local NGO B)
[30] PHIVOLCS Volcanologist 2

The tension between different scientific groups may make it difficult for NGOs to know what science to use and what to trust. This is undoubtedly not a situation unique to the Philippines and, thus, emphasises the need for NGOs to understand the context of science in the country within which they are working. At the same time, three PHIVOLCS scientists[31] referred to their negative experiences of working with certain INGOs, which appeared to have made them distrustful of these agencies.

The tension and distrust also extended to the relationships between government scientific agencies. The institutional approaches of hazard assessment, monitoring and warning in the government[32] were highlighted as a major problem in the run up to and during Reming: there was an apparent lack of agreement as to whose responsibility it was for anticipating this event. The different mandates of government agencies may also not be clear to NGOs wishing to use their data. PHIVOLCS Geologist 2 highlighted the confusion that arises over the difference between their and the MGB's fault maps:

> *'MGB have its fault map but not all of them are active, so PHIVOLCS we publish only active fault maps so that's also a source of confusion amongst NGOs: 'how come we have fault here but you don't have fault here'. They think it's the same but they don't know that some faults of MGB are…inactive or geological lineament, or structures. But for us it's the active faults. So we have less* [fault] *lines compared to MGB.'* (PHIVOLCS Geologist 2)

If NGOs wish to utilise science, they need to be aware if the science they are utilising is appropriate. Scientists also need to be aware of how their information might be used and communicated, beyond what they had originally envisaged[33]. PHIVOLCS Volcanologist 1 emphasised that it is important to communicate that science will not '*solve 100%*', which is well exemplified in the case of lahar risk at Mayon. A good and final example of the challenge of anticipation, even with scientific analysis, in the context of multi-hazards was shared by one

[31] PHIVOLCS Geologist 3; PHIVOLCS Volcanologist 2; International Volcanologist
[32] Noted by PHIVOLCS Geologist 1 and 3
[33] PHIVOLCS Volcanologist 2

NGO interviewee. The example emphasises the importance of managing the expectations amongst NGOs and communities as to the limits of scientific assessments:

> *'The community they even ask* [for science] *because they assess their land based on their five senses and they would want to further develop this, that's why they ask for opinion from the science community. Incidentally the UP* [University of the Philippines] *colleagues…are also conducting a study related to landslide and we facilitated, we introduced to them this community* [and]…*they went and did this study …after the study, they presented this to the community, even to the Mayor, and from that…the community, already drafted and came up their own counter disaster plan. …once there will be a typhoon or rain, will happen, they know the landslide, where it will be and how many and the possible scenarios will happen once there will be a typhoon. Incidentally, the sad event that happened…an earthquake happened last February 6th, with 6.8 magnitude and the epicentre is just two hours away from the community and because of this earthquake landslide happened and cost 40 lives in the community, and …more than half of the community – had been buried because of these landslide. …PHIVOLCS had been asked: "why the earthquake happened – is there a fault or a trench identified in the area?" Before the earthquake happened, in the data from the PHIVOLCS they could not find any fault or trench in that perimeter… The area is not earthquake prone. …it came out that there is a hidden fault in the area but previously satellite they could not find; even other instruments they could not find that there will be a possible earthquake in that area...'* (Deputy Director, National NGO)

## 8.3 Summary

In a dynamic environment such as Mayon, the changes in lahar hazard over the short and long-term emphasise why NGOs need to encourage the review of community-based hazard assessments over time. The two scientific strategies for assessing and anticipating the timing, location and occurrence of lahars respectively address the long- and short-term hazard.

The long-term approach to anticipating lahars is via hazard mapping (Figure 8.1) and, given the finite resources of scientists to make and disseminate map updates, the government scientists appear to have adopted a conservative approach to lahar mapping. The map requires some interpretation by the user but essentially it implies proneness to lahars in the long-term, with an indication of increased proneness in the southern sector of the volcano. In the short-term, the areas highly prone to lahar will appear to be under a greater threat of lahars than those in areas of low proneness. However, in the long-term, those in the low proneness areas are also highly threatened because they are exposed to high-magnitude (low-frequency) lahars. This distinction emphasises why it is important to anticipate both the timing and the magnitude of the event. Without having some sort of quantification of recurrence interval of lahars of different magnitude, it is difficult to see how NGOs and decision-makers alike can make informed decisions regarding long-term strategies (see Newhall and Hoblitt, 2002). Furthermore, it emphasises why communication of science is essential in order for residents to understand the threat posed by lahars.

Many of the areas affected by Typhoon Reming have been re-classed as highly prone in in the updated lahar hazard map (2011). This is in spite of this event being a high magnitude, low frequency event. This amendment could represent the utilisation of modelling, changes in topography and channel configuration due to Reming (resulting in these areas being more prone to frequent lahars) or a conservative approach to mapping. At the same time, however, the map has not obviously considered an event larger than the Reming lahars.

In the short-term, the anticipation of lahars relies on the utilisation of rainfall thresholds. Rather than adopting the conservative approach observed in the mapping, the critical rainfall intensity threshold for lahar initiation is much higher than the rainfall recorded for the 34-year history of lahar events. This threshold may better reflect the rainfall that actually falls on the slopes of Mayon, but it also appears to incorrectly assume that Rodolfo and Arguden's (1991) measure of at least 10 mm of rainfall in 10 minutes equates to a threshold of 60 mm/hour. Although limited, the lahar record available in this study demonstrates that the threshold for lahar initiation varies between events and further investigation of this, as well as the influence of previous eruptions on this threshold, is required.

Furthermore, as illustrated during Reming, it is not sufficient to simply rely on a threshold; the threshold needs to be accompanied by an appropriate scenario in order for stakeholders to prepare for the disaster. The Reming disaster illustrates why communication of uncertainty is essential because the utilisation of 'worst-case' scenarios creates unrealistic expectations of scientists. Furthermore, it is not enough to know that this case might happen: being anticipatory means determining the likelihood of it occurring; however there is an apparent lack of probabilistic analysis of these types of scenarios at Mayon.

Table 8.2 summarises how the three components of anticipation (location, timing and severity) have been addressed by the lahar hazard mapping and critical rainfall intensity threshold, as well as the extent to which these two methods have considered the influence of other hazards. Generally, the map depicts relative levels of hazard whilst the rainfall threshold reflects absolute hazard. In regard to both strategies, it appears that the weakest link in the anticipation chain is severity, which is implied in the hazard map but this assumes that users can interpret the different levels of lahar threat. Studies in other volcanic settings, however, have suggested that communities often find it difficult to interpret maps (Haynes et al., 2007). In the context of the rainfall threshold, the link to severity is more ambiguous. Figure 8.10 presents how the links between the components of anticipation are reflected in the short and medium term. This diagram emphasises that the weakest component is severity (magnitude).

Table 8.2 Methods for anticipating the location, severity and timing of lahar.

| ***Assessment method*** | ***Anticipation of lahar hazard*** | | | ***Consideration of multi-hazards?*** |
|---|---|---|---|---|
| | ***Location*** | ***Severity*** | ***Timing*** | |
| Lahar hazard map | Yes | Implied but requires interpretation | Relative (i.e. higher or lower proneness) | The map cannot reflect the rainfall trigger and, importantly, does not state that lahars can occur without an eruption. |
| Critical rainfall intensity threshold | Applicable to the whole volcano, rather than individual channels. Location can be anticipated by using this threshold alongside the hazard map and knowledge of recent eruptions. | Ambiguous – more research required | Absolute | Real-time monitoring of weather system; adjustment of threshold based upon time since last eruption. |

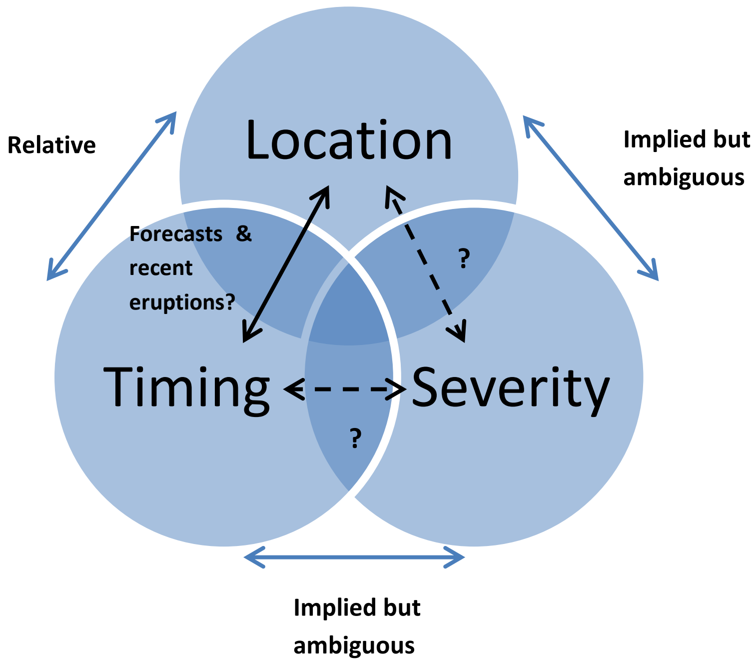


Figure 8.10 Venn diagram of the overlapping components of anticipation and how these link in the short and the long-term through the assessment methods adopted for lahars at Mayon. The blue arrows refer to the long-term (hazard map) and the black arrows to the short-term (critical rainfall intensity threshold).

In order to account for how hazards and changes in the environment influence the lahar hazard profile over time and space, both the hazard map and critical rainfall intensity threshold have to be updated to (for example) reflect the influence of recent volcanic eruptions. Making these changes appears to rely, in part, on the experience and judgement of scientists and local government. This chapter, however, demonstrates why it is important for NGO practitioners not to simply accept the science that is available, but to critically evaluate its applicability and identify its limitations, especially in instances when these are not well communicated. Good communication between NGOs and experts is also an essential means of ensuring that NGOs and the communities they represent are aware of the uncertainty and limits of the available information.

From the sample of interviews analysed, it appears that, when compared with the scoping study to the Philippines in September 2010, engagement between scientists and NGOs is growing. In the context of the government scientists, this engagement is still one way, with few collaborative approaches to scientific hazard research involving NGOs and communities compared to the approaches of academic and not for profit scientific organisations (e.g. the Manila Observatory). Whilst scientists are more open to sharing their information and engaging with NGOs, it is up to NGOs to approach scientists, but scientists (across government and academia) are not always easy to access owing to their resource constraints, limited capacity and the cost of purchasing scientific information. The added complication when addressing multi-hazards is the institutional division of hazards across the government scientific agencies.

In addition, there is perhaps a need for government scientists to better appreciate the role of communities in the 'coproduction' of knowledge rather than just being recipients of scientific information (see Landström et al., 2011). Records of lahar events could be enhanced through the monitoring of the incidence of small lahars and notable changes in channels by local communities. The local government of Albay appear to recognise the role of communities in monitoring rain gauges and rainfall critical thresholds, however they appear to approach it through existing government structures (Barangay Captains) rather than necessarily engaging with those most vulnerable.

# Chapter 9: Synthesis of research findings

The objective of this final chapter is to synthesise the findings from parts one and two of the research. The chapter begins with an overview of the research, which identifies the major themes that emerged. This overview is followed by discussion of the two main components of the research question, which are (1) multi-hazard concepts and their assessment and (2) multi-hazard knowledge: the role of science and community knowledge. The wider implications of the research relating to the literature, policy and practice are then discussed. The chapter ends with a series of conclusions and recommendations for NGO practitioners and for future research accompanied by a list of contributions this research has made to NGO risk reduction work and multi-hazard research.

## 9.1 Overview of the research

The aim of the EngD research was to determine the extent to which NGOs do and can implement multi-hazard assessments and whether they use science for this purpose. Three research objectives were outlined in Chapter 1, the first of which was to determine a conceptual framework for multi-hazards (see Chapter 2), which proposes that the term multi-hazard comprises more than one hazard and the interrelations between hazards. In Chapters 4 and 5, this understanding of multi-hazards was used to establish whether NGOs are adopting a multi-hazard approach in their community-based assessments (the second objective). The findings indicated that although NGOs tend to assume their methods assess multi-hazards they may not account for all the hazards in a location and even less so for the interrelations between hazards. This situation was owing to a number of factors discussed in Sections 9.2 and 9.3, including a lack of integration of science, particularly amongst Head Office interviewees, and constrained spatial and temporal scales of assessment. Building on these findings, the third objective looked to examine the reality of multi-hazards – [particularly the interrelations between hazards owing to their notable absence in NGO approaches] – in the context of an actual case of multi-hazards (Chapter 7). Given the emphasis on the integration of science throughout the research, in Chapter 8 the role of science in assessing multi-hazards was explored using the example of anticipating lahar hazard at Mayon Volcano. Chapter 8 also build on earlier findings from Chapter 5 by further exploring the engagement between scientists and NGOs in the Philippines.

In order to satisfy the aim and objectives, the research adopted an interdisciplinary approach. The data collection and analysis were divided into two parts, comprising a total of three studies, which involved mostly qualitative methods and involved a number of stakeholders (see Table 3.11). The purpose of the first part was to determine current approaches to hazard assessment across the NGO sector and whether these incorporate a multi-hazard approach. The second part was to explore the reality of multi-hazards and the application of community and scientific knowledge in anticipating these, within an actual case. The order of studies reflects the progression of research from an initial exploratory approach to a more specific and contextualised understanding of a case, informed by the preceding studies. The research was pursued in this sequence to ensure that the approaches of NGOs were at the forefront of the research, since they represented the partner, end-user and focus of the research. As emphasised in Chapter 3, applied research was the driving philosophy behind the methodology. It was advantageous to base studies B and C in the Philippines, standing its status as a truly multi-hazardous environment, as well as a developing country, where a number of NGOs work, including CAFOD at the research commencement.

The research was designed to explore the concept of multi-hazard and the application of multi-hazard assessments in the context of NGO risk reduction work. Through this analysis, three additional key interrelated themes emerged: multi-hazard knowledge, scale of analysis and anticipation of multi-hazard disasters. Combined with the theme of multi-hazard, these encapsulate the four major thematic areas within the research, which are discussed within the following two sections:

- in order to be anticipatory, it is necessary to adopt a multi-hazard approach;
- multiple hazards and the interrelations between hazards were observed to emerge over different spatial and temporal scales;
- in order to identify multi-hazards over these scales it is necessary to integrate community and scientific knowledge and expertise;
- ensuring the inclusion of this relevant knowledge is therefore essential for the purpose of anticipating disasters.

Whilst the limits of generalising from qualitative research are acknowledged (see Chapter 3), by synthesising the results from the three-study multi-methods research project, it is possible to propose wider implications of the research findings that are applicable beyond the context of this research. Where possible, these findings are compared to other studies in order to support or challenge the findings from the research (Bazeley, 2007). In the following discussions 'Head Office interviewee(s)' refers solely to those interviewed at NGO Head Office in the UK during Study A. 'In-country interviewee(s)' applies to any NGO interviewee based in countries where their organisation is implementing projects, so this also applies to the Philippines participants and, therefore, Studies A and B.

## 9.2 Multi-hazard concepts and multi-hazard assessments

Historically, policymakers have emphasised the need for a multi-hazard approach (UNEP, 1992; UNISDR, 2005), but there has been little exploration of the meaning of this term in the context of DRR and humanitarian and development NGO work. However, in light of recent disasters (namely the Tōhoku earthquake-tsunami disaster), there has been growing recognition that DRR strategies have to be able to address the interrelations between hazards (Ashdown, 2011; UNISDR 2011). The literature review identified that different terminology is often used interchangeably to describe these interrelations, with some terms – such as 'interacting' – causing confusion. The research therefore has major implications for how the term multi-hazard is defined and framed within policy directed towards practitioners, as it is widely recognised that practitioners often get frustrated with the academic language used within DRR terminology (Twigg, 2007).

### 9.2.1 A conceptual framework for multi-hazards

In this research, the framework has been informed by both literature and an actual case of multi-hazards. From the review of the literature, two components of multi-hazard were identified: (1) more than one hazard and (2) the interrelations between hazards. The concept of hazard interrelations was divided into four interdependent processes or characteristics (Table 9.1).

Table 9.1 Summary of the types of hazard interrelation identified from the literature and analysis of the Reming lahars case study.

| **Causation** | **Amplification or alleviation** |
|---|---|
| *Hazards that generate secondary events, which may occur immediately or shortly after the primary hazard (including cascading hazards).* | *Hazards that exacerbate or reduce future hazards (applies to the same or different hazards).* |
| **Coincidence** | **Association** |
| *The simultaneous occurrence of hazards in space and/or time, resulting in compounding effects or secondary hazards.* | *Hazards that increase the probability of a secondary event, but which are difficult to quantify.* |

Each of these interrelations emerged (to varying degrees) during the analysis of the Typhoon Reming lahars disaster to the extent that the characteristic termed ‘amplification’ had to be revised to reflect the fact that previous hazards can alleviate, as well as exacerbate, the impact of future hazards; for example, the August 2006 lava flow shielded the provincial capital from the Reming lahars. The hazard interrelations are summarised in Table 9.1.

In the analysis of the Reming lahars, it was apparent that the location, timing and magnitude of the lahars were owing to the combined influence of different hazards over space and time. The case also demonstrated that a type of hazard (e.g. lahar) might manifest along a spectrum of hazards (Lee and Jones, 2004), which may have different destructive qualities but are perceived to be the same phenomenon by communities. This continuum of mass movement hazards has been observed in other cases. For example, the transition from rock slide to debris avalanche to debris flow during the landslide that destroyed Barangay Guinsaugon in Southern Leyte (Philippines, 2006; Guthrie et al., 2009). Debris flows often have long-run out distances and the result was the total inundation of Guinsaugon.

The Reming lahars disaster emphasises that anticipation in multi-hazard settings needs to account for hazards occurring simultaneously or in close succession, whilst also considering how hazards in the past might have exacerbated conditions for future hazards. The disaster also demonstrates why it is crucial to anticipate the occurrence of secondary hazards, since the resulting impact was greater than the aggregation of the individual risks (Marzocchi et al., 2009). If the typhoon had occurred without triggering lahar, then the disaster would have resulted in a very low number of deaths since the majority of these were a consequence of the lahar.

Non-hazardous processes, for example the migration of channels (e.g. upstream of Barangay Padang; see Chapter 7), also exacerbated the impact of Reming. The links between the local natural environment and hazards are well recognised in the literature (Woo, 1999). There are two reasons for mentioning these non-hazardous processes. The first is because Chapter 4 indicated that Head Office NGOs tend not to account for local environmental processes, or simply attribute these to the influence of climate change. The second reason is so as to avoid confusion amongst practitioners regarding what constitutes a hazard interrelationship and what simply applies to the analysis of hazards more generally.

Some writers consider the instances when non-hazardous processes, for example heavy rainfall, trigger more than one hazard in their definition of interrelated hazards (e.g. Kappes et al., 2012). Essentially, this equates to coincidence in Table 9.2. However, in the case of the Reming lahars, it was the fact that the lahars (and floods) were triggered during a typhoon (and not just heavy rainfall) that was of interest. This distinction is important, since the typhoon also brought strong winds and storm surge, thus compounding the impact and hampering the relief efforts to reach lahar affected residents. However, what is important to emphasise to practitioners is that assessing or anticipating the occurrence of hazard interrelations cannot be divorced from the factors that influence the occurrence of hazards more generally, which includes the non-hazardous processes like, in the case of mass movements for example, heavy rainfall and deforestation.

The categories in Table 9.1 are a useful means of labelling hazard interrelationships. However, during the research it was apparent that a number of general aspects of hazard assessment require emphasis because they are perhaps not being readily accounted for in NGO hazard assessments. The points listed below emphasise multiple hazards, the dynamics of hazards and their interrelations and are supported with examples from the case study:

- many areas are exposed to more than one hazard (e.g. Albay);
- one hazard might trigger a cascade (sequence) of hazards (e.g. Typhoon Reming triggered lahars);
- independent hazards may occur simultaneously or in close succession and, in doing so, may trigger secondary hazards (e.g. the possibility of a Mayon eruption and typhoon occurring simultaneously);
- the occurrence, magnitude and impact of hazards might change owing to the influence of previous and, possibly, different hazards that have occurred (e.g. influence of previous eruptions and Typhoon Milenyo prior to Reming);
- the source of the hazard may be beyond the geographical boundary of the community (e.g. upstream lahar initiation);
- unexpected hazards might be manifestations of frequently occurring hazards (e.g. in the case of Mayon, the Reming lahars were much larger than what was expected from a typhoon).

In the Reming case study, it was also observed that previous hazards and disasters might influence the impact of future disasters by altering the risk perceptions of decision-makers and residents so that, particularly in the case of communities, they do not adequately prepare (Johnston et al., 1999). Part of the problem is owing to the reliance on past experience and the fact that community knowledge did not account for lahars of this size during a typhoon.

In all three studies, the two factors that emerged as being essential to the assessment of multi-hazards were (1) the consideration of appropriate spatial and temporal scales of analysis and (2) the range of knowledge utilised in the assessment. The limited application of these comprises one of the main reasons why NGO practitioners are struggling to address multi-hazards in their assessments.

### 9.2.2 NGO hazard assessments: constraints on a multi-hazard approach

In the context of NGOs, the results of the interview analysis echo the findings of the 2011 HFA mid-term review (Louw et al., 2011) and the Chair's Summary (2011) of the 2011 Global Platform for DRR, which found that practitioners are not adopting a multi-hazard approach to their DRR work. The following discussion summarises the constraints upon a multi-hazard approach to hazard assessment by NGOs.

There are a number of methods within PHVCAs that allow for the identification of more than one hazard, for example hazard mapping, time-lines, hazard prioritisation and focus group discussions. The extent to which these successfully identify the range of hazards and their interrelations in a given place is in part reliant on the scales that are considered and the balance of external and internal information and knowledge. These two considerations are undermined by institutional (funding), organisational (capacity) and individual (assumptions, biases and skills of facilitation) influences on the PHVCA design and process.

In spite of the perception that the PHVCA tools adopt a multi-hazard approach, it was apparent that they are constrained by their design (selection of top three hazards) and the adoption of an analytical 'lens' (e.g. DRR and CCA). These lenses appear to be associated with preconceived ideas regarding which hazard is of greatest concern and how hazards might change over time, the emphasis being on climate change. The implications of these are significant, since NGO interviewees (in particular those at Head Office) had preconceptions that climate hazards and climate change necessitate a consideration of future hazards and risks, whereas DRR is historical and deals with 'known' hazards[1] (*cf.* Sperling and Szekely, 2005). However, the case of the Reming lahars demonstrated that 'known' hazards might manifest in ways unanticipated by communities (and to some extent scientists).

The strong climate change narrative was particularly apparent during interviews with UK Head Office NGO participants. In the Philippines, the influence of CCA was evident but with less emphasis and representatives of three agencies emphasised the local context, implying that climate change may not fully explain the changes in hazards being observed on the ground. This may have been owing to the fact that these interviewees were still determining how to address climate change. However, two of the in-country interviewees from Study A also appeared less concerned with the labels of DRR and CCA which were deemed to come from 'the north'. Furthermore, from interviews with environmental stakeholders in Moorea, French Polynesia, Walker et al. (2014) also found that the circumscribed CCA narrative amongst NGOs was a mismatch with the local perceptions and understanding of environmental change.

The fact that NGO interviewees emphasised that their PHVCA tools adopt a multi-hazard approach suggests they assume that methods are neutral and will identify the full range of concerns; however, this assumption has been demonstrated in this and other studies to be questionable (e.g. Wallace, 1997; Twigg, In press). Some Head Office NGO interviewees did acknowledge possible bias within the CCA narrative, as well as potential prejudices within the PHVCA process; for example, hazard prioritisation is based on the communities' perception of hazards, which might be influenced by the seasonality of the events and the prioritised hazard might reflect the remit or capacity of the NGO supporting the project (*cf.* Bowman and White; 2012, Twigg, In press). A few interviewees also observed that communities were more

[1] Policy coordinator – DRR (HD INGO G)

concerned with their day to day problems, rather than the potential threat of future disasters, which was also identified during the interviews with communities affected by the Reming lahars: '*the threat of hunger is more real than the threat of a lahar flow'* (Executive Director, Local NGO Ph3). The analytical lenses are, therefore, partly to help constrain and manage the number of concerns the communities might want to consider, which may be beyond the scope of the funding and the capacity of the NGO (*cf.* Twigg and Bottomley, 2011). It is essential, however, to ensure that this approach is not influenced by preconceived notions regarding the types and natures of different hazards, as was observed in Chapter 2.

The challenge of ensuring the implementation of rigorous multi-hazard assessments is also compounded by the need to maintain a balance between analysis and action. As emphasised in Chapter 2, the PHVCA process is underpinned by the philosophy of participatory action research, which emphasises the need for actionable results (Mercer, 2012; Peters-Guarin et al., 2012). In terms of the foundations of participatory hazard assessment, Anderson and Woodrow (1998: 45) state that focus should be on 'gathering the 'right' information quickly but that too often the 'wrong' (or unnecessary) information is gathered too slowly'. As such, there is a balance between ensuring actionable results and safeguarding sufficiently objective and rigorous analysis. However, there was a sense from the interviews in Chapters 4 and 5 that the balance would sometimes shift in favour of action at the expense of thorough analysis of risk of multi-hazards, particularly given the urgency Head Office interviewees placed on addressing climate change. There is therefore perhaps a need for NGOs to acknowledge the time required to implement a multi-hazard assessment.

Head Office interviewees emphasised that their tools are flexible and some Philippines NGO interviewees stressed the importance of the process of PHVCA over the tools. However, the emphasis on tools was apparent by the fact that the majority of NGOs in Study A had developed their own tools (despite them all being fairly similar) and that there was also an urgency to create tools to specifically view things through a 'climate lens'. In Study B, staff of Local NGO Ph3 shared some of their experiences of attempting to adapt and adopt too many tools to the extent that (in the end) they did not fully understand the PHVCA process. It was apparent from Chapters 4 and 5 that the success of the PHVCA process relies heavily on the skill of the facilitator. In the context of multi-hazards, the onus is on the facilitator to ensure that the community make the connections between, for example, hazards and their environment. There was little questioning, however, of whether facilitators have the necessary skills to make the links between hazards or whether they have the technical expertise to bring additional (scientific) insight (see Section 9.3).

Chapters 4 and 5 indicate that community-based multi-hazard assessments are constrained by the limited spatial (community) and temporal (community memory) scales of analysis. At the same time, however, during the analysis of the Reming lahars it emerged that the interrelations between hazards were most apparent at the community level. For example, the influence of landslides upstream of the Masarawag channel and the capping of potential lahars by the 2006 lava flow created a varied impact of lahars across the lahar affected southern sector. The channel switching upstream of Barangay Padang is not a hazard interrelationship, but it also emphasises the need for community assessments to consider (1) change in the environment over the short-term (years) and (2) the need to consider processes upstream of the community (Lee and Jones, 2004). Therefore, whilst the findings from the Reming lahars case study support the recommendation that multi-hazard assessments should reflect NGOs' requirements of a community-based approach to multi-hazard assessment (see Marzocchi et al.'s, 2009 and Kappes et al.'s, 2012 emphasis on end-user requirements), these analyses have to be situated within an understanding of the natural system. However, the results from Chapter 4 indicated that, in terms of larger (e.g. national or regional) analytical scales, NGOs are typically concerned with socio-political systems and the wider institutional setting, rather than hazards and risks. A few NGO interviewees in the UK and Philippines noted either the need to include these scales of hazard and risk assessment or that they were considering broadening their scope to account for larger natural systems (e.g. water basins), but this was mostly in the context of climate change. Furthermore, the pervasiveness of community-based approaches and a lack of capacity to implement larger geographical assessments mean that these are not widely being applied.

Using the example of lahar hazards, the changing frequency, location and magnitude of lahar hazards over the short and long-term emphasises why NGOs must encourage systematic review of hazards and risks in terms of changes in the local environment and not just because of the acknowledgement that societies are dynamic (*cf.* Anderson and Woodrow, 1998) or driven by the narrative of climate change. It was acknowledged by some Head Office interviewees that DRR PHVCAs have tended to focus too much on the past and have not been particularly anticipatory. The absence of an anticipatory approach to all hazards (and not just those related to climate change) is of concern. Head Office Interviewees suggested that reviewing hazard profiles over time either did not occur or was a weaker component of the PHVCA process. Generally the NGO interviewees in the Philippines acknowledged more than interviewees at Head Office that hazards, vulnerabilities and risks change over time, but the noted practical challenges of ensuring communities or local government would support reviewing the hazard assessment questions whether such review would actually occur (see Chapter 5). NGO interviewees, particularly at Head Office but also in the Philippines, were particularly concerned with what the future might bring and so were acknowledging the need to utilise climate science in order to anticipate what future threats. The climate change discourse emphasises the need to address emergent and unanticipated risks (CCCD, 2009); however the case of the Reming lahars demonstrated that strengthening anticipation is required across risk reduction. The role of both science and community knowledge in anticipating and assessing multi-hazard threats is explored below.

## 9.3 Multi-hazard knowledge: the role of science and community knowledge

The execution of this research and its findings support the proposition that multi-hazard assessment requires an interdisciplinary approach (Ritchey, 2006; Tweed and Walker, 2011). There is also an expectation that science can assist in anticipating multi-hazard disasters (Ashdown, 2011). However the assessment of hazard interrelations is not widely embedded within hazard science and is published within academic journals or written in scientific language that is not readily transferrable to a non-scientific audience (*cf.* Solana et al., 2008). A number of studies are also confined to case studies in developed countries (e.g. De Pippo et al., 2008; Marzocchi et al., 2009; Kappes et al., 2010, 2011), where data on past disasters tends to be more plentiful compared with that in developing countries (Rodolfo and Arguden, 1991). In these contexts, knowledge from the community is essential since it might be the only information available to scientists regarding the hazard context (Mercer, 2012).

During interviews with Head Office participants, it was apparent that the inclusion of science was the exception, whereas it was more readily applied in the Philippines, albeit to a limited extent. Lack of understanding, relevance and cost were all identified as current barriers to the integration of science, particularly in the Philippines. The following discussion emphasises that a combination of barriers, including the perceptions and assumptions of NGOs about science and scientific engagement, are preventing the integration of science with community knowledge for the purpose of NGO assessments of hazards.

### 9.3.1 Perceptions of science and community knowledge

All the NGOs interviewed emphasised the importance of community knowledge in the PHVCA process owing to the emphasis on community participation and ownership (see also Twigg and Bottomley, 2011) and, particularly in the Philippines, the fact that the knowledge residing within communities might be the only information available. Whilst there is the opportunity to include outside expertise through key informant interviews or via secondary information (Twigg, 2004), in general Head Office interviewees noted that key informants would not tend to include hazard scientists. The need for direct engagement with scientists emerged more strongly during the interviewees with Philippines NGO staff, however it was noted that scientists are unlikely to come to the community level and, as such, the NGO staff have a key role in resourcing and communicating science to communities. In contrast, amongst Head Office NGO interviewees there was mixed opinion as to whether communities and scientists would directly engage, but some appeared dismissive of this level of engagement and the emphasis was generally on secondary information. There appeared to be an underlying assumption that facilitators (e.g. NGO staff) could provide this role in their capacity as educators (*cf.* Cronin et al., 2004). A small number of NGO interviewees at Head Office and in the Philippines noted that NGOs are primarily comprised of social scientists rather than natural scientists or hazard experts. As such, this implies that they might not be in a position to provide the community with the additional information they require in order for them to identify and prioritise hazard risk. However, experiences from the Philippines suggest that NGOs have an essential role in instigating and brokering the engagement between scientists and communities, as well as sourcing and translating science for use by communities. A key aspect of training of facilitators and staff should therefore be the enhancement of these skills in order for practitioners to be able to critically evaluate the science that is available (see Chapter 8), which is discussed further in section 9.4.2.

Furthermore, the results from this study suggest that NGOs are not necessarily aware of what science is of use to them. The findings from Chapters 4 and 5 demonstrated that there is a tendency to couch science solely within the context of climate change owing to the concern with anticipating climate change and climate risk. With limited exceptions, this tendency was particularly apparent amongst the Head Office NGO participants. In practice, however, the few examples of integrating climate science within PHVCA pertained more to climate variability (*cf.* Tanner and Mitchell, 2007), owing to the mismatch between the temporal and spatial scales of their analysis (*cf.* Birkmann and von Teichman, 2010). The emphasis on climate change has highlighted the need for NGOs to use science, however it is also unhelpful because it associates science primarily with information that is not typically at the resolution of local communities and which is particularly complex. Moreover, it removes the focus from considering the local factors that might drive environmental change and exacerbations of hazards and risks by assuming that these are caused by global phenomenon (*cf.* Walker et al., 2014).

Part of the problem appears owing to an uncertainty amongst NGOs regarding what science might be of use and, at points, a hesitancy and reluctance from Head Office interviewees to integrate science for fear of it removing emphasis from vulnerability and undermining the legitimacy of the participatory process. Some writers have, referring specifically to participatory action research within DRR, acknowledged the contribution of both scientific and local knowledge (e.g. Cronin et al., 2004; Mercer et al., 2010; Peters-Guarin et al., 2012). However, the traditional discourse underpinning participatory risk assessments has tended to be critical of outsider perspectives, instead emphasising community knowledge (e.g. Chambers, 1997; Anderson and Woodrow, 1998).

In origin, PHVCA was not designed as a substitute for scientific analysis nor as the single source of information, rather it was a method for communities to identify their own risks and solutions to alleviate those risks (Chambers, 1997; Peters-Guarin et al., 2012). Over time, however, PHVCAs have come to represent the entirety of NGO hazard assessment for DRR projects, rather than being supported and integrated with natural science. There is therefore a need to question the perceived purpose of NGO multi-hazard assessments and whether it is possible to have one integrated assessment that brings together natural science and local and indigenous knowledge. In the Philippines, NGO practitioners appeared to be integrating science to a greater extent, but were constrained by a series of practical barriers.

### 9.3.2 Lessons from the Philippines

The Philippines is a multi-hazardous country, thus the findings from the interviews conducted there provide essential understanding of the integration of science in the context of multi-hazard assessments. Given the findings of the interviews with Head Office staff in Chapter 4, it was surprising to discern that science was being used by NGOs in the Philippines. 15 NGO representatives representing 11 agencies (five international, two national and four local) across studies A and B discussed, to varying extents, the incorporation of science into their community-based hazard assessments most of them unprompted by the researcher. Some of these interviewees couched science in the context of climate change, but they also spoke of its application in risk reduction more generally, making specific reference to comparing the findings from the community with scientific information during the PHVCA process. During Study B, interviewees emphasised that the process should begin with the communities' knowledge before comparing it with a scientific perspective. This sequencing has been endorsed by others who have attempted to integrate science into participatory risk assessments (e.g. Cronin et al., 2004). However, whether such sequencing allows for an impartial assessment of hazard, or simply endorses the hazards preselected by focusing on technical strategies to reduce risk, needs to be resolved. One NGO interviewee emphasised that the process of integrating science should be iterative. The fact that information and knowledge need to be constantly reviewed and assessed (which parallels the emphasis within this thesis on updating hazard assessments and hazard profiles over time) during and beyond a project cycle needs to be stressed (see Duncan et al., 2014).

What was most strikingly different between the Head Office and Philippines NGO interviewees was that the latter did not hold the same preconceptions, hesitancy and reluctance to incorporate science in the PHVCA process. They also encouraged rather than dismissed the direct engagement between scientists and communities. The Filipino interviewees instead referred more to the practical barriers of integrating science and implied that their reliance on community knowledge was partly due to the fact that there was often no scientific information available. Barriers to integrating science related to accessibility (including the high cost), availability (its relevance and whether it is up to date) and communication. Informal relationships between NGOs and scientists are generally the norm in the Philippines, particularly owing to the lack of resources to spend on science and a lack of scientists. From the interviews, and more particularly from the informal meetings and participant observations, it emerged that there is contention over the source of science, particularly whether it is from the official government source or from academia or non-profit research groups. It was, however, noted by NGOs that the government scientists have limited capacity at the local level, so there is a need to engage with other scientific groups. From the small sample of scientists interviewed, there appeared some concern amongst government scientists as to the trustworthiness and credibility of non-government science, whilst both an NGO representative and an academic queried the credibility of government landslide assessments. Three government scientists also noted some negative experiences of working with NGOs, of which the majority appeared to be international NGOs. Further research is required to determine whether one scientific group is more generally utilised by NGOs than the other and to further ascertain the perspectives of scientists regarding engaging with NGOs.

A further notable lesson from the Philippines studies relates to recent emphasis on using science to anticipate disasters (see Ashdown, 2011). The analysis of the Reming lahars provided the opportunity to explore this assertion in the context of a multi-hazard disaster. The three components of the anticipation of geophysical hazards are location, timing and severity (Rees et al., 2012). Lahars are a persistent threat at Mayon, but it was the magnitude of the lahars that was most surprising. The Typhoon Reming lahars disaster emphasised that these are interdependent components since the lahars were a low-frequency high-magnitude event that, consequently, inundated some areas not regularly affected by lahars. Some affected communities had no memory of lahars (e.g. Barangays Binitayan and Tagas[2]), which emphasises that community knowledge was insufficient for the purpose of anticipating this event. The disaster also challenged the assumption that NGOs can provide additional information to communities that '*they've just not had the opportunity to get informed about'* (Policy Advisor – Climate Change, Development NGO) because the NGOs had also not appreciated the fact that a typhoon could bring lahars as large as those that occurred during Reming. However, the scientists were also surprised by this event, despite having previously identified most of the areas that were impacted as being prone to lahar in their 2000 hazard map (Figure 7.14; Chapter 7). PHIVOLCS scientists and one member of the local government felt that the problem was owing to a lack of communication of the forecast and real-time rainfall that fell during Reming, which meant that they were not anticipating lahars of that magnitude. The problem was compounded by the fact that it was underdetermined which technical agency should be responsible for typhoon triggered post-eruption lahars, since they fall into the category of both volcanic and weather-related hazards. Furthermore, the worst-case scenario, which was utilised by the local government at the time, was an underestimation of the Reming event. Similarly, the 2011 Tōhoku earthquake multi-hazard disaster was much larger than the worst officially expected scenario in that area (Marzocchi et al., 2012b). Both these disasters emphasise the importance of anticipating cascading hazards and the need to ensure that the magnitude of these events is sufficiently accounted for. Therefore, whilst it is essential to integrate science for the purpose of multi-hazard assessment, it is also important for NGOs to be aware of its limitations and where it needs to be enhanced.

[2] Now resident of Barangay Anislag

The evaluation of lahar hazard assessments in Chapter 8 demonstrated why it is important for NGOs to evaluate the available science and not just accept it. Information pertaining to the critical rainfall threshold was derived from interviews with scientists and local government and then compared with the available data. The findings suggest that the applicability of critical rainfall intensity thresholds in dynamic volcanic environments needs further investigation, particularly the high value of the rainfall threshold and the influence of previous eruptions on this threshold value. It is acknowledged that the findings from the analysis are limited by the lack of representative rainfall data and information regarding the timing and magnitude of previous lahars, which emphasises the need for further studies. The absence of representative data also emphasises why science integration may rely on direct engagement with scientists based on their expertise, rather than readily available information.

The evaluation of the lahar hazard map identified two concerns. The first related to the difficulty of communicating lahar hazard based on a long-term map; fundamentally the map is not incorrect, it simply cannot reflect the short- to medium-term changes in lahar hazard that might affect communities, which were observed to have occurred between the production of 2000 lahar map and the occurrence of the Typhoon Reming lahars in 2006. The second concern relates to the existence of more than one map of the same phenomenon, but with different results. Non-scientists must be able to initially interpret these maps but also be aware of the analysis behind them in order to determine which one is most credible. In the context of the PHIVOLCS map (Figure 8.1; Chapter 8) this might be challenging since the lahar hazard zones are not accompanied by any explanation and it appears up to the user to interpret the map (*cf*. Haynes et al., 2007).

What appears weakest, and was also a notable problem during Typhoon Reming, is the anticipation of lahar magnitudes. In acknowledging the limited data for lahar analysis at Mayon, it might not be possible to predict or determine the probability of every outcome so emphasis should be on identifying the circumstances that limit or encourage future possibilities, an idea emphasised in systems thinking (see Allen, 1988; Gunderson and Holling, 2002; Tweed and Walker, 2011). A recommendation for future research on Mayon lahars is to explore the possibility of critical rainfall intensity thresholds that reflect the potential size of the lahar that might be triggered, whilst at the same time managing the expectations of what science can deliver.

Many of the influences of previous hazards and disasters (e.g. increased siltation from Typhoon Milenyo) were undoubtedly easier to identify after the Reming disaster (*cf.* Tweed and Walker, 2011). The difficulty of mapping lahar hazard in a dynamic environment like Mayon highlights an opportunity for engagement between communities and scientists. Systematic monitoring of lahars by local communities could help to enhance the lahar database and observations of changes in the environment could inform scientists of increased levels of risk. Other opportunities for engagement between communities and scientists and the integration of their knowledge are discussed below.

**Opportunities for integrating science and local knowledge**

In Chapters 4 and 5, it was emphasised that community are aware of their situation, but they need assistance in interpreting and making links, for example, between changes in their environment and their hazard profile. Facilitators in the PHVCA process were identified as providing that assistance, but in the Philippines it was also identified that scientists can similarly help to interpret the observations being made by communities and provide insight beyond what the NGOs can provide. In the context of the Philippines, three opportunities for integrating science with information or knowledge from local communities were observed:

(1) community information and scientific data (e.g. eye witness accounts of the Reming lahars compared with rainfall collected at the PAGASA rain gauge (PHIVOLCS, 2006a; Orense and Ikeda, 2007));

(2) community information and scientific information (e.g. NGO interviewees described comparing the PHVCA findings with scientific hazard maps);

(3) community information and scientific knowledge (e.g. observations of heightened occurrence of lahar in Barangay Padang were interpreted by scientists as increased risk to Padang, albeit retrospectively; PHIVOLCS, 2007a).

NGO interviewees noted that communities can provide the detailed information relating to their hazards and the scientists provide the interpretation and explanation for the phenomena communities are experiencing. Information and observations from communities could be enhanced through more systematic means of monitoring phenomena (e.g. the community-based rain gauge programme at Mayon). Monitoring of lahars by communities needs to be managed and informed, as there have been instances at other volcanoes where these types of engagement have not worked well. For example, communities at Santa Ana (Ilamatepec) Volcano in El Salvador criticised the local NGO's selection of lahar observers, on the grounds that that their homes were too far down slope (Bowman and White, 2012). This emphasises that if NGOs want to encourage monitoring and observation by communities, they need to ensure that they are sufficiently informed of the most appropriate approach.

NGO interviewees emphasised that communities know their situation best and, in the Philippines, it was particularly emphasised that scientists need information from the communities (*cf.* Anderson and Woodrow, 1998), owing to a lack of scientific monitoring in certain areas. Furthermore, from the observations made of scientists speaking during events attended by the researcher (see Appendix A) and from their descriptions of the types of public engagement they are involved in (e.g. IECs), it appears the engagement between scientists, NGOs and communities is typically one way, driven by top-down science. Across the interviewees, it was emphasised that, with assistance, communities can interpret the phenomenon they are experiencing. Perhaps, therefore, there is an opportunity to adopt a more collaborative approach encompassing a fourth type of engagement: (4) ‘community knowledge and scientific knowledge’ and an emphasis on the co-production of knowledge (e.g. Landström et al., 2011).

The integration of community and scientific knowledge presents an opportunity to assess multi-hazards, however there are a number of barriers that need to be overcome in order to utilise scientific information and expertise. The findings from the research have important implications relating to DRR and current policy for science integration.

## 9.4 Implications for policy and practice

Since the research commenced, there has been growing emphasis in the DRR discourse on the need to adopt an all risks approach, coupled with concern over the growing complexity of disasters and the need to consider ‘simultaneous’, ‘sequential’ and ‘synchronous’ events (UNISDR, 2011). These recommendations are accompanied with advocacy for the utilisation of science for risk assessments and anticipating disasters (Ashdown, 2011; UKCDS, 2013; Southgate et al., 2013). The following discussion is, therefore, divided into two parts; the first part addresses DRR practice and policy and the second relates to knowledge transfer and academic partnerships.

### 9.4.1 Disaster risk reduction policy and practice

Whilst the research had a largely practical focus, the research conclusion comes at a critical time for DRR policy. In March 2015, the UNISDR will launch their post-2015 framework for DRR, which will replace the HFA. At the same time, the post-2015 sustainable development agenda and climate change agreement are being finalised and there is great emphasis on the synergies and complementary overlaps across these agreements (UNISDR, 2014b). The new DRR framework is likely to greatly emphasis the integration of DRR and CCA (UNISDR 2013, 2014b). However, the analyses in Chapters 4 and 5 indicate that, in spite of existing ideological moves to more integrated approaches, there appears a dominance of climate change, which is maintained by assumptions regarding the nature of hazards and risks and the role of science in assessing them. CCA is deemed to be more anticipatory (concerned with future, unknown, threats; *cf.* Venton and LaTrobe, 2008; McBean and Ajbade, 2009), more scientific and (at times) more urgent than the hazards traditionally associated with DRR. In spite of a literature supporting the need for (at least partial) integration (see Chapter 2), practical implementation is more divided, except in the case of those in-country interviewees who felt that these were one and the same. These findings have major implications for the successful implementation of a multi-hazard approach since assumptions are being made prior to analysis regarding the relative threat of different hazards. Furthermore, it highlights the discrepancies between NGOs in developed countries and those they fund (*cf.* Thompson, 2012), since it is actually those on the ground in this research who appear less driven by climate change discourse and more aware of the need to integrate science across hazard assessments than those in Head Office. This finding emphasises the importance of activities on the ground informing policy.

The fact that DRR is perceived by some NGO interviewees to be less anticipatory than CCA illustrates why an integrated approach is so critical. The Typhoon Reming lahars disaster demonstrated dramatically the need for greater anticipation of multi-hazard disasters related to both climate and geophysical hazards. The research has thus emphasised that approaches which account for all hazards and their interrelations are essential for the purposes of reducing risk. The absence of a true multi-hazard approach within NGO hazard assessments is, therefore, a matter of concern and questions whether NGOs are succeeding to adopt an accountable and 'do not harm' approach to their community-based DRR (*cf.* Benson et al, 2001). Placing emphasis on one hazard at the expense of another may inadvertently create vulnerability within communities.

What is also troubling is that recent updates regarding the post-2015 framework have made no reference to the term multi-hazard (UNISDR 2013, 2014b). This is in contrast to the HFA, within which it was noted that 'an integrated multi-hazard approach to disaster risk reduction should be factored into policies, planning and programming' (UNISDR, 2005: 4). The concern is that there is an assumption at the UNISDR that the multi-hazard problem has been satisfactorily addressed. The evidence presented here would counter this and recommend that policy makers and DRR practitioners advocate the importance of a multi-hazard approach (see UKCDS, 2013), whilst also providing guidance within the post-2015 framework as to what such an approach entails.

The HFA included risk assessment as a key priority for DRR and the UNISDR argue that significant progress has been made in risk assessment (UNISDR, 2014b). In contrast, the research presented here and the findings of others (e.g. Louw, et al. 2011; Shepard et al., 2013; UKCDS, 2013) suggest that more needs to be done to improve the quality and coverage of hazard and risk assessments, particularly ensuring that these adopt a multi-hazard approach (UKCDS, 2013). Two methods by which a greater emphasis on multi-hazards could be achieved are (1) emphasising its importance in the integration of DRR and CCA and (2) linking it with the notable emphasis on resilience within these draft frameworks.

The theory and application of resilience has grown in importance in recent years (e.g. Ashdown, 2012; Mitchell and Harris, 2012; Alexander, 2013; Turnball et al., 2013). Whilst the definition of resilience is contested (see Chapter 2), it has been likened with many aspects which also relate to the study and assessment of multi-hazards:

- dynamic systems (i.e. that risks and hazards are dynamic);

- the interconnectivity of systems (e.g. Walker and Salt, 2006);
- the need for interdisciplinary knowledge, including science (e.g. Bahadur et al., 2010; Interagency Resilience Working Group, 2012; Southgate et al., 2013);
- anticipating change and disasters (e.g. Bahadur et al., 2010; Ashdown, 2011; Interagency Resilience Working Group, 2012).

Resilience is proposed as a key component in the post-2015 framework for DRR (UNISDR, 2013). Thus, there is an opportunity to re-emphasise the need for a multi-hazard approach in all aspects of DRR, but particularly risk assessment and anticipation.

The research addresses the multi-hazard problem in the context of a key stakeholder group (NGOs) who have not been included to any significant extent in, or contributed to, the discourse regarding multi-hazards and their assessment. In Chapter 2, it was highlighted that NGOs have been increasingly recognised as key actors in efforts to alleviate poverty and reduce risk. If the role of NGOs in DRR is truly recognised by international and local governments and donors (*cf.* Jennings and Barrow, 2001), then DRR policy-makers must acknowledge the limited capacity within these agencies to implement some of the associated recommendations, including the integration of science. The UNISDR recognise the need to 'strengthen the technical and scientific capacity' at the national and local level (UNISDR, 2014b); however whether efforts to strengthen this capacity are to be directed at NGOs (and not just presumably government) is not stated. The recent advocacy in DRR policy for more scientifically informed risk assessments for anticipating disasters presents an opportunity to encourage greater integration of science within NGOs; but, ensuring this policy is put into practice requires addressing the barriers to, and shortfalls in, integrating science into NGO DRR work identified in this thesis.

### 9.4.2 Knowledge transfer and NGO-academic partnerships

The implications of the research findings in the context of knowledge transfer and NGO-academic partnerships are drawn from both the research findings as well as the reflexive position of the researcher. The research process embodied knowledge transfer (between the researcher and NGO partner) as well as an academic-NGO partnership.

The post-2015 framework for DRR is likely to emphasis the role of science within DRR. The UNISDR (2014: 12) emphasise that 'the scientific and technical committee should be revitalized as an international science advocacy mechanism…to [amongst other things] promote and support the availability and application of science to decision-makers'. The variable levels of scientific understanding amongst non-scientist decision-makers is widely recognised (Martí et al., 2008; Solana et al., 2008) and, using the example of NGOs, the knowledge transfer approach being advocated by the UNISDR is hindered by a number of barriers. Furthermore, given the recognised need for an interdisciplinary approach to addressing multi-hazards, there is a need to question what is currently achievable within the humanitarian and development sector, given the constraints identified in this research.

In the 'pre-zero' post-2015 framework draft, academia and research are encouraged to:

> focus on the evolving nature of risk and scenarios in the medium and long terms; increase research for local application and support to local communities and authorities' action; and support the interface policy-science for effective decision making (UNISDR, 2014b: 14).

Anticipating the aforementioned scenarios requires a multi-hazard approach, but this thesis has demonstrated that NGOs do not always adopt this approach or long-term perspectives, which emphasises the need for partnerships with academia and research institutions. Furthermore, the implication is that academia and research institutions should work with NGOs in order to reach 'local communities', since NGOs work closely with them. Lastly, the research has highlighted the absence of practical guidance alongside multi-hazards and science policy for practitioners, which is addressed in the following section.

The partnership with CAFOD was based on an existing interest in science from the CCA and DRR. The results in Chapters 4 and 5 suggest that NGOs do value this type of engagement, but that there are both practical barriers and, particularly at the Head Office level, ideological barriers, such as the perception that DRR is a more practical, less scientific approach than CCA, that have to be overcome.

**Changing attitudes and providing guidance for science integration**

In his review of science and technology for disaster risk reduction, Basher (2013: 3) argues:

> that policy makers and the disaster risk reduction community will readily accept scientific and technical information when it is understandable, relevant to the interest of those involved and affordable…However, achieving this in practice can be difficult where political processes and decision-making are influenced by interest groups that do not share these values and priorities.

Reflecting on both the findings from the interviews in Chapter 4, along with the researcher's experience of participating in the sector, the research is in agreement with Basher's statement that science needs to be accessible, relevant and affordable; but the findings also suggest that science will not necessarily be adopted in practice, even if these conditions are met (*cf.* Fischer, 2000). Amongst the Head Office interviewees in particular, misconceptions about the role of science, as well as the emphasis on community knowledge and the concern that science (and hazard) will overshadow vulnerability, suggests that more needs to be done to encourage the uptake of science. This relates to the sociological analysis of public understanding of science briefly reviewed in Chapter 2, where science might be consciously ignored because it is perceived to be peripheral (Irwin and Michael, 2003). Furthermore, many NGO interviewees emphasised that the community know their situation best, therefore it is questionable whether NGO practitioners truly perceive a need to integrate other sources of knowledge and information. Lastly, the fact that practitioners tend to link science with climate change is a key finding for policy makers and knowledge transfer researchers, since it emphasises the importance of ensuring science is effectively communicated and understood.

In spite of the concern that attitudes may not be easily to changed, since commencement of this research, there has been increasing interest from both the academic and NGO sector for better integration of science (e.g. Green, 2013). For instance, in June 2012 the researcher participated in the Interagency Resilience Working Group workshop on integrating science, participants of which included the technical advisors of many UK based international NGOs (see Appendix J). The feedback survey requested that participants share their opinions of the 'three core barriers to assessing multi-hazards'. Ten workshop participants answered this question and, in spite of the small sample size, these answers support some of the findings of the research (see Figure 9.1). The emphasis on knowledge, and particularly science, as well as the admission of the lack of multi-hazard approaches within agencies and capacity to undertake these, reflects the need to provide guidance and resources for addressing these needs. The examples of scientific engagement shared in Chapters 4 and 5 pertained more to the initiative of individuals to integrate science rather than a decision at the organisation level that scientific integration was required, which emphasises why it is important that the technical advisors quoted in Figure 9.1 are recognising lack of scientific capacity as a barrier to multi-hazard assessments. This reflexive stance was not generally adopted during the interviews with similar Head Office staff in Chapter 4, perhaps implying a shifting attitude to awareness of a lack of science within hazard assessments.

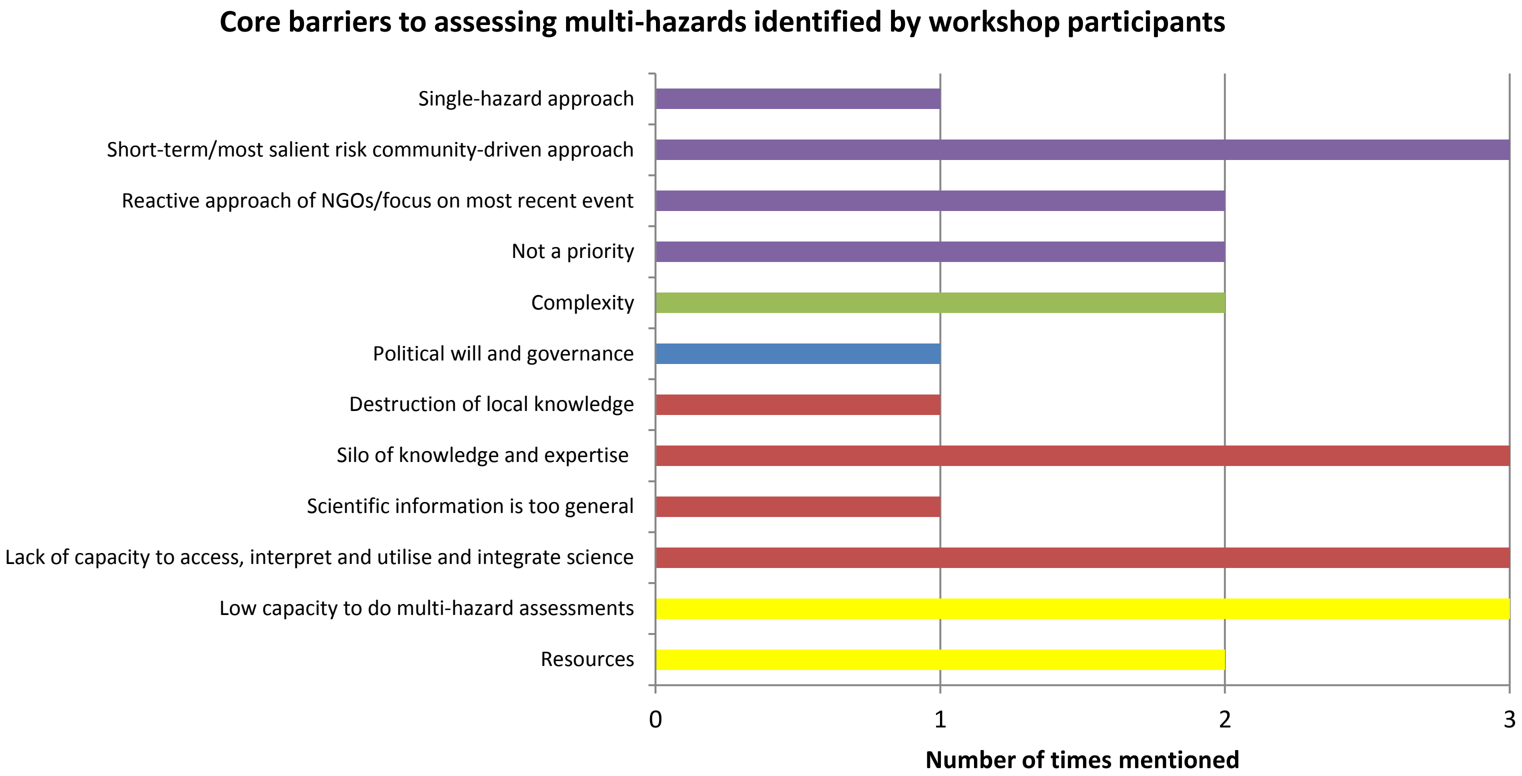


Figure 9.1 Summary of the barriers identified by ten participants of the Interagency Resilience Working Group workshop in June 2010. The original answers can be observed in Appendix J.

In order to address the short-fall in guidance regarding the integration of science, this EngD research was used to inform a set of guidelines for the integration of science in humanitarian and development planning and practice for NGO practitioners (see Duncan et al., 2014). The aim of these guidelines is to enable practitioners to ask the questions that will ultimately help them to apply science in their planning and operational decision-making (a copy of the guidelines is available in Appendix K).

The guidelines address a number of concerns related to science integration identified in this research, including the conceptualisation and understanding of science, access to and availability of science and how to determine the credibility of scientific information. The document emphasises the importance of multi-stakeholder co-production of knowledge, the need to build scientific capacity within NGOs, the importance of partnering with scientific agencies in advance of crises and how to overcome certain pitfalls practitioners face when integrating science into their activities. The guidelines could therefore arguably be used to increase professionalism within NGOs (*cf.* Benson et al., 2001).

The document illustrates that integrating science requires an iterative and flexible approach, thereby ensuring that the inclusion of science does not serve to simply support predefined outcomes (a concern noted in Chapter 5). There are five key components, which may have to be revisited several times over the course of a project or engagement (see Figure 9.2). Given the emphasis on the skills of the facilitator in participatory approaches to community-based hazard assessment, the guidelines provide to facilitators a basis from which to consider science within community-based hazard assessments.

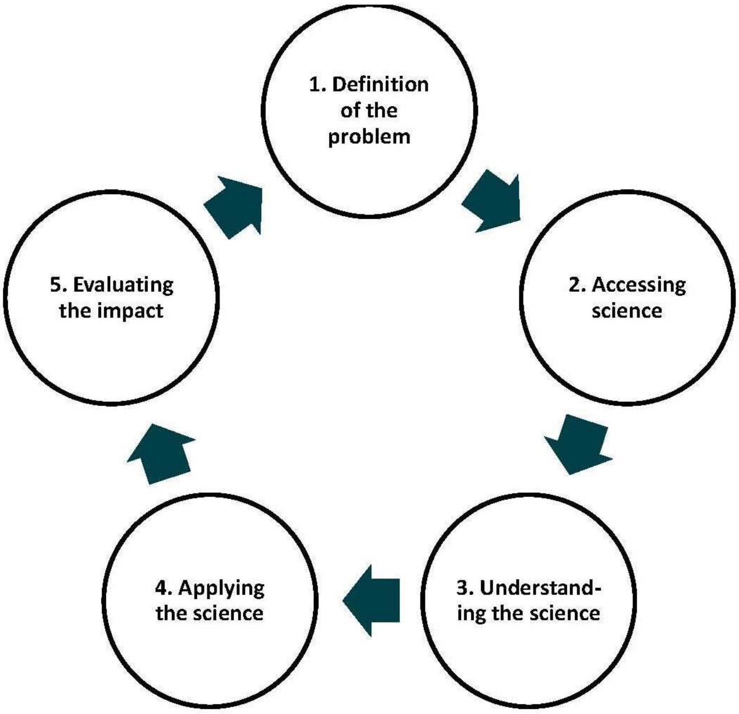


Figure 9.2 The five components of integrating science addressed in the guidelines. Source: Duncan et al. (2014; fig. 3: 5).

The research found a slight preoccupation amongst Head Office NGOs with the development of toolkits for implementing their work. Therefore the guidelines are classed as a 'toolkit' and are not designed to be exhaustive. Instead, they embody a key methodological recommendation from this research: it is not possible to design a tool to fully address the problem of multi-hazard assessments, since the problem relates to wider concerns regarding the lack of scientific engagement and perceptions of DRR and CCA amongst individuals and organisations. The guidelines serve as an initial step in addressing scientific integration across DRR and CCA.

The guidelines are a useful document for both those who have made the decision to engage with science and those who are yet to be convinced, since it justifies why science might be of use and emphasises the importance of evaluating the impact of science. Whilst the impact of science is beyond the scope of the EngD research, it emerged in the context of practitioner's concern that their work (as opposed to scientists') assists those in poverty and that they need to justify, for example to management, why they should invest in science.

The research reflects the challenges from the perspective of NGOs, but it also identified some barriers facing scientists and academics looking to engage with NGOs (see Chapter 8). In the context of interdisciplinary multi-hazard research, the challenge of integrating science is attributable in part owing to the traditional reductionist approaches to scientific endeavour (Chambers, 1997), which was partly echoed in the institutional approaches to addressing different hazards in the Philippines. Definitions of science within risk reduction are shifting to compensate this (e.g. ICSU, 2008; UNISDR, 2009c) and the need for application of science is being emphasised (e.g. Southgate et al., 2013; UNISDR, 2014b). However, Irwin and Michael (2003: 37) note that those scientists who engage in 'causes' run the risk of abandoning their identities as 'proper scientists'. The challenge of the EngD was balancing the need to deliver academic rigour against ensuring usable outputs for CAFOD and the wider NGO sector, most of whom do not traditionally undertake substantial long-term research projects. The researcher had to gain acceptance from both academics and NGOs, who have different concerns and expectations.

### 9.4.3 Reflections on the interdisciplinary and NGO-academic partnership-based approach

Being critical of a sector that also represents a research partner was always going to be challenging (see Mercer, 2006), but a necessary means of ensuring the implementation of rigorous research. The fortunate position of being in the partnership with CAFOD meant that the researcher had access to the wider NGO sector and was thus able to evaluate its methods generally. The research therefore embodies findings from across the sector, rather than a critique of individual agencies.

The research addressed the need presented by CAFOD, which was to explore the method of multi-hazard assessment. However, after the commencement of the project, it quickly emerged that this need was driven by a concern within individuals at CAFOD as to the lack of scientific appraisal of their work. As a result, the research required adaptation to address both these concerns.

Conducting research within a dynamic sector was insightful. At project commencement, CAFOD were one of the few UK based NGOs investing in scientific enquiry. However, during the research the policy and institutional arena began advocating the utility of science for DRR, as well as the need for NGOs to underpin their work with evidence (Green, 2013). There were two levels to the EngD research endeavour: the first was the topic of research (multi-hazards) and the second was the context of the research (the changing context of the NGO sector). The EngD research was therefore situated within the partnership, the trends that emerge within the humanitarian and development sector and the overarching paradigms of risk reduction. It was challenging to keep abreast of these changes and also not to be swayed by the trends within the sector. Above all, the emphasis was on maintaining a balance between academic research and practical application, which in a sense echoes the difficult balance PHVCA facilitators have to maintain between multi-hazard analysis and action (see Section 9.2.2).

Conducting research with NGOs as subjects, end users and partners allowed for the unique opportunity to have both an 'insider' and 'outsider' perspective into NGOs; but it also highlighted the need to ensure that expectations of the NGO, the university and the student reflect what is achievable in this type of engagement (see Roper, 2002). Initially the research was solution-driven rather than analysis-driven, with the initial focus on multi-hazard assessment tools for implementation at the community level, but without prior questioning of what a multi-hazard approach to assessment really entailed. However, due to good communication between the partners, it was soon agreed that the project had to address the problem rather than solely focus on the solution. These experiences have implications for future NGO-academic partnership based doctoral research.

## 9.5 Conclusions and recommendations

The thesis has explored the concept of multi-hazards, their assessment by NGOs and the application of community and scientific knowledge in the context of a multi-hazard disaster case study. An overarching message from the research is that humanitarian actors can only achieve an anticipatory approach to DRR if they consider the multi-hazard context of their operations. Considering multi-hazards requires scientific as well as community knowledge and the analysis of hazard interrelations over different spatial and temporal scales. Consequently, the concluding points are structured around the three main concerns. These are followed by recommendations for future research and NGO practitioners and a summary of the main thesis contributions.

### 9.5.1 The characteristics of multi-hazards and their assessment

In spite of the fact that multi-hazard approaches have been emphasised within development, environmental and DRR literature for several decades, there lacks clear guidance on what such an approach entails. The conceptual framework for multi-hazards presented in the thesis provides agencies with the means of adopting a 'multi-hazard lens' to their analysis.

Multi-hazard assessments necessitate the consideration of more than one hazard but also the interrelations between hazards. At present there is a lack of widely agreed terminology to describe these interrelations, but for the purpose of this research they are considered as four interdependent processes: amplification, association, causation and coincidence.

Of importance is the consideration of how hazards over different spatial and temporal scales are interrelated and consequently cause or exacerbate future hazards. The case study of the

Typhoon Reming lahars emphasises the need to anticipate, prepare for and respond to the simultaneous occurrence of different hazards, whilst also determining how previous hazards might have amplified or reduced the location, timing and severity of the anticipated event.

### 9.5.2 Current NGO approaches to multi-hazard assessment

NGOs assume their toolkits address multi-hazards. In reality, the extent to which multi-hazards are incorporated is constrained by preconceived ideas about risk, the capacity of NGOs and communities to address these different hazards and the emphasis on community knowledge at the expense of the entire range of knowledge (including scientific) required for multi-hazard analysis. Moreover, current methods focus more on multiple hazards than the interrelations between hazards.

There is a need for NGOs to recognise that multi-hazards cannot be assessed by adopting a single-lens (e.g. DRR), a single methodology (PHVCA) or a single source of expertise (communities). Rather than developing a tool, the emphasis should be on ensuring that those facilitating the process of assessment have the skills and training to identify multi-hazards and the information and expertise that could assist in the assessment of these hazards.

### 9.5.3 Factors constraining a multi-hazard approach: knowledge and scale

The research demonstrated that the two major determinants of multi-hazard assessment are knowledge and scale. It is only through the consideration of scales beyond the level of communities (both temporally and spatially) and the inclusion of multi-stakeholder knowledge (beyond the community and NGO) that multiple hazards and their interrelations can be assessed and anticipated.

The identification of the interrelations between hazards necessitates the consideration of hazards over different spatial and temporal scales (Kappes et al., 2011). There was a tendency amongst Head Office interviewees in particular to consider future and dynamic risk solely in the context of climate change, with other ('DRR') hazards perceived to be 'known'. The Typhoon Reming lahars disaster emphasises that consideration of emergent and unanticipated hazards and risks must go beyond climate change. In the case of the Reming lahars, the disaster represented an unexpected manifestation and magnitude of a known hazard, which emphasises the importance of scenario planning and DRR strategies that adopt a multi-hazard approach and account for all three components of anticipation: location, timing and severity (see Rees et al., 2012). The frequently changing environment and levels of risk from lahars at Mayon also serves to emphasise why it is essential that NGO practitioners encourage communities to periodically review their risk and that scientists and communities collaborate in order to stay abreast of these changes and their implications for risk.

Despite greater integration of science by NGOs in the Philippines, there are a number of perceived and real barriers to the integration of science by NGOs and, as a consequence, to the successful implementation of a multi-hazard approach. At the same time, the evaluation of lahar hazard assessment at Mayon demonstrates that the available science might not always be communicated, understood or provide the level of information required to fully anticipate multi-hazard disasters. If NGOs are serious about adopting a multi-hazard approach, they need the skills to evaluate the appropriateness of the science they choose to integrate or assistance from someone who does. Furthermore, owing to the uncertainty surrounding the assessment of hazards and the degree of expert judgement that might be required in making these assessments (e.g. Mayon lahar hazard map), it may be necessary to directly consult with the scientist regarding the level of risk rather than simply accept the available information.

Given the findings of the research, the growing policy on the utility of science needs to acknowledge that (1) NGOs might be users of science and (2) that they might not yet be sufficiently capacitated to begin utilising it. Given the lack of capacity, these policy statements need to be accompanied by practical guidance, particularly to address the gap regarding the uncertainty of what science to use and how to use (e.g. Duncan et al., 2014; Appendix K).

### 9.5.4 Recommendations for future research

Interdisciplinary research was a necessary means of addressing the topic of research, but it was challenging to address the breadth of the problem within the constraints of the time and resources allocated to doctoral research. The scope of research question allowed the study to address the context of the end-user (NGOs) and the concept of multi-hazards and the reality of their assessment. On reflection, both of these comprised a research project in itself. However it was necessary to address both owing to a relative lack of literature regarding each of these at the time of project commencement. Consequently, this research has provided the first step in the field of NGO related multi-hazard research and application. A suggestion for future research would be to address the context of NGO multi-hazard assessments and the study of multi-hazards within separate research projects by building on the analysis contained here.

The case study was selected on the grounds that it would help inform the developing theory of multi-hazards, rather than necessarily confirm it. The researcher therefore recommends that future research looks to other cases in order to build case understanding in this field. Given that practitioners in the Philippines are particularly engaging with science, it would be of benefit to explore cases outside of the Philippines, but still in developing countries, to build on the limited number of interrelated hazard case studies in this context.

Only a small number of scientists were consulted in this research with regard to their engagement with NGOs so future research should look to explore some of the initial findings from this research, such as the dominance of top-down science and some of the negative experiences of their working with NGOs. Related to this is the need to address in more depth the power struggles between scientific groups and whether NGOs are more able to access science from certain sources rather than others.

Specific to the research endeavour, areas for improvement include sourcing a dedicated translator for community interviews. Furthermore, with hindsight, longer engagement with some of the DRR stakeholders would have been beneficial because they required more time to build up a relationship with the researcher before sharing critical information.

Finally, the focus of this research has been on the 'hazard' element of the risk equation. As a consequence, future research should look to incorporate the analysis of hazard interrelations within vulnerability and risk analysis.

### 9.5.5 Recommendations for NGO practitioners

Throughout the thesis, but particularly within this final chapter, a number of recommendations for NGOs have been emphasised. Here, they are re-emphasised for clarity.

Whilst it is acknowledged that NGOs work in challenging environments and under the constraints of institutional funding, there are a number of ways in which they can begin to address some of the practical concerns regarding multi-hazard assessments. NGOs need to increase their engagement with scientists, but also their own ability to identify what science is of use and to critically evaluate its suitability. Some of the greatest initiatives regarding the assessment of multi-hazards and the utilisation of science for this purpose were observed to be attributable to key individuals in agencies. This emphasises the need for agencies to employ people with the appropriate skills and the ability to recognise when external assistance is required. It should also be acknowledged that accessing science and scientific information may require funding. However, in the absence of the availability of scientific monitoring, communities can have a key role in observing and recording environment change, hazards and disasters. This information can be interpreted together with scientists in order to determine current and changing hazard profiles. Implementing means of systematically recording this information will strengthen baselines of hazard information.

There is a need for hazard assessments to better incorporate the visualisation of hazards and risk over space and time to help identify multi-hazards. Assessments should emphasise the dynamic nature of hazards, that past events are not always an indication of the future and that there is a need to review and reassess hazard risk overtime.

Although it is acknowledged that these are in part driven by institutional funding, there is a need to remove the circumscribed analytical lenses (e.g. CCA), since these appear to limit the analysis of multi-hazards. This is not to suggest that climate change is not considered, but instead that it is considered alongside the wider hazard and risk profile of communities. It is recommended that NGOs utilise the recent emphasis on resilience as a means of re-emphasising and highlighting to donors the facets of a multi-hazard approach and the support agencies need in order to sufficiently anticipate multi-hazard disasters. The Post-2015 Framework for DRR could also be an opportunity to emphasise this message.

### 9.5.6 Thesis contributions

A number of findings from this research are of application to the humanitarian and development sector and multi-hazard research. In addition to providing the basis for further analysis of the field, the thesis has made several key contributions to the academic and practitioner sectors. Firstly, the research has addressed the absence of a conceptual framework for understanding multi-hazards for the humanitarian and development NGO sector. The case of the Typhoon Reming lahars has contributed to this and the wider academic understanding of interrelated hazards. Evidence has also been provided, primarily from interviews with UK Head Office NGO staff and international, national and local NGOs in the Philippines that both supports and challenges the assumption that NGOs are not utilising science for the purposes of hazard assessment. The research has also encompassed the first academic critical evaluation of NGO (multi-)hazards assessments and the utilisation of science for this purpose. As mentioned earlier, the research has been instrumental in informing a set of guidelines for NGO practitioners on how to integrate science into their work (see Duncan et al., 2014; Appendix K). These guidelines, entitled 'integrating science into humanitarian and development planning and practice for enhancing community resilience', have addressed the gap in the advocacy for greater use of science that is unaccompanied by guidance for NGO practitioners. Although designed for NGO practitioners, the guidelines have practical application for other decision-makers.

In the context of the science of multi-hazards, the research has contributed to the understanding of rainfall triggered lahars at Mayon, involving the creation of a lahar database of the last 34 years of lahars. Finally, the research has led to collaborations with other multi-hazard researchers, resulting in the facilitation and co-organisation and running of the first workshop on interacting natural hazards, which was held in February 2014 at University College London (see Budimir et al., 2013).

## Appendix A: Events attended during the EngD as observer, participant, facilitator or convenor that were either hosted by or included humanitarian and development organisations

Table 1 presents the events attended in the UK and Table 2 presents the events attended in the Philippines. Note that this only includes academic conferences that were attended by NGOs.

Table 1 UK Events

| Event | Date | Host | Location | Role | Details |
|---|---|---|---|---|---|
| *CAFOD Humanitarian Seminar* | 22/10/2009 | CAFOD | Brighton | Participant | The first aim of the seminar was to help CAFOD strengthen its humanitarian work by developing a strong and coherent strategy for the next five years. The second aim was to enable participants to better understand the challenges they are facing as they develop their work under the key headings of protecting civilians, reducing risks to people's lives and providing strong and effective assistance to men, women and children during crises. The researcher participated in group discussions, met different stakeholders and observed the event. |
| *Disaster Risk Reduction for Natural Hazards: Putting Research into Practice* | 4-6/11/2009 | UCL | London | Participant | Academic conference deliberately targeted at decision-makers, including NGOs. The researcher presented a poster and identified participants for interviews. |

| | | | | | |
|---|---|---|---|---|---|
| *CEDRA Workshop* | 19-21/04/2010 | Tearfund | London | Participant | Participatory workshop designed to help organisations to assess the impacts of climate change and environmental degradation at organisational level and to choose the most effective adaptation options across all sectors that they work in. The researcher presented the UCL-CAFOD partnership, received training on a toolkit and met with key NGO stakeholders. |
| *World Vision-UCL Microinsurance brainstorm* | 26/04/2010 | University College London (UCL) | London | Facilitator | Workshop to explore the opportunities for establishing partnerships between Insurance Providers, Academic Institutions and International NGOs in order to provide disaster risk insurance for the vulnerable poor. The researcher acted as a note taker. |
| *Strengthening Climate Resilience (SCR) UK Consultation* | 27/05/2010 | Department for International Development (DFID) | London | Participant | Opportunity for agencies working on the issue of integrating climate change into disaster risk management work to learn from others. It was designed to provide the needed space for practitioners, policy makers and academics to share their knowledge and expertise with a view to improving current and future practice. The consultation was designed to provide a space to consider and share approaches to integrated working in order to improve disasters and development programming more broadly. The researcher took part in the discussions and met key NGO stakeholders. |
| *Community-Based Adaptation Workshop* | 12/07/2010 | Practical Action | London | Observer | As part of the Global Initiative for Community Based Adaptation, Practical Action organised this event to draw together mainly UK based practitioners in an ongoing narrative amongst the international CBA community. The researcher observed this event. |

| | | | | | |
|---|---|---|---|---|---|
| *Disasters: Improving the evidence base for prevention, resilience and emergency response* | 13/10/2010 | The Royal Society | London | Observer | As part of International Day for Natural Disaster Reduction 2010, this one day conference aimed to create an environment in which the UK 'disasters community', whether from private sector, academia, non-governmental organisations or government, can learn about existing initiatives, share their work and discover better ways to coordinate and collaborate with each other. The day was primarily comprised of presentations with little opportunity for discussion. |
| *Innovation in DRR* | 27/01/2011 | Christian Aid | London | Observer | This event was organised to share and discuss the learning from innovation in DRR with a wide range of DRR and climate change practitioners. The researcher was primarily an observer but had the opportunity to meet with key NGO stakeholders. |
| *Humanitarian Futures Programme Roundtable Discussion* | 13/05/2011 | King's College London | London | Facilitator | The review of learning on science humanitarian-policy dialogue. The researcher participated in and facilitated the group discussions. |
| *Interagency Resilience Working Group Workshop - Integrating Science into humanitarian and development work to enhance resilience, linking science and traditional community knowledge* | 21/06/2012 | Catholic Agency for Overseas Development (CAFOD) | London | Participant | The workshop focused on linking climate and natural hazards science with traditional community knowledge. Alongside Help Age International, CAFOD drew together over 30 representatives from International NGOs and leading researchers from the top universities in the UK. The learning event was part of a series of workshops being organised by the Programme Partnership Arrangements (PPA) learning group on resilience of which CAFOD is a core member. Researchers presented on current challenges in using scientific information and applying uncertainty in the NGO sector, as well as sharing good practice examples of using scientific information and traditional knowledge. The researcher presented the concept of multi-hazards and |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | then participated in the group discussions, observing NGO staffs' engagement with hazard science. |
| *Disaster Risk Management in the Post-2015* | 04/07/2012 | Overseas Development Institute (ODI) and UK Collaborative on Development Sciences (UKCDS) | London | Participant | This workshop was an early opportunity for stakeholders to come together to debate the key features of disaster risk management in an international policy landscape beyond 2015. The researcher participated in the group discussions. |
| *Tsunami Disasters: How Effective has Science Been For Mitigation Planning and Disaster Relief?* | 06/09/2012 | UCL | London | Observer | An interdisciplinary workshop for disaster practitioners and tsunami scientists to identify how science can be used more effectively in tsunami mitigation, planning and relief. The researcher primarily observed. |
| *Resilience workshop* | 20-21/09/2012 | CAFOD | London | Observer | For advisors, regional and international managers to discuss and decide what resilience means for CAFOD's work and practical ways forward. The researcher primarily observed. |
| *NGO-Academic-Business Collaborations for Enhancing disaster risk reduction, response and relief* | 08/02/2013 | Aon Benfield | London | Facilitator | Innovative one-day workshop organised by the Aon Benfield UCL Hazard Centre at University College London in partnership with Aon Benfield, CAFOD and HelpAge International. It will present an opportunity to investigate the practical applications of risk mapping and modelling tools, the roles of research and training, and the benefits of knowledge exchange partnerships. The researcher facilitated one of the group discussions, took notes throughout the day and formed links with DFID in the context of multi-hazards. |

| | | | | | |
|---|---|---|---|---|---|
| *Interacting and cascading natural hazards* | 14/02/2013 | UCL | London | Convenor | This workshop brought together those with an interest in the field to evaluate the practical applications of current research and to define key directions for future investigations into the interaction of natural hazards. Co-organised and co-convened with Mirianna Budimir (University of Southampton) and Joel Gill (King's College London). The researcher also presented the Typhoon Reming lahars case study to participants. |
| *Identifying concrete opportunities for further integrating science across humanitarian and development planning to support community resilience* | 02/07/2013 | UKCDS | London | Facilitator | The objectives of the workshop were to discuss opportunities and mechanisms for a more systematic integration of science across existing humanitarian and development planning processes. The workshop represented a collaboration between the University of Reading, CAFOD, UKCDS, British Geological Survey, HFP amongst others. The researcher produced the workshop report and lead on the guidelines for integrating science, which were written after this event. |
| *Useful Science Initiative* | 09/12/2013 | University of Oxford | Oxford | Participant | The purpose of attending was to review this initiative for making scientific publications accessible and understandable to non-scientists. The researcher participated in group discussions. |
| *DRR Policy Lab* | 14/02/2012 | The Royal Society | London | Observer | The aim of the event was to bring together researchers and policy-makers who work on disaster risk reduction. The purpose was a two-fold: (1) to increase the use of relevant science in DRR policy and action, and (2) to encourage further development of science for DRR amongst researchers within the UK, regionally and globally. Participants discussed whether better partnerships are needed between scientists and practitioners, whether there is a need for better education on both sides and whether incentives and rewards are required. The |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | guidelines for integrating science were presented at this event. |

Table 2 Philippines Events

| Event | Date | Host | Location | Role | Details |
|---|---|---|---|---|---|
| *Exchange of Southeast Asian CAFOD Partners on Climate Change Adaptation and Disaster Risk Reduction in Land Use Planning and Management* | 18 - 25/09/2010 | CAFOD | Iligan City and Osamiz, Mindanao | Participant | Training for CAFOD's southeast Asian partners on DRR and CCA. Attendees included participants from Timor-Leste, Myanmar, Philippines, Sri Lanka, Cambodia and Indonesia. The researcher presented working concepts on multi-hazards based on her experiences from her earlier visit to Albay. |
| *[Name unknown]* | 23/09/2012 | PAGASA | Quezon City, Metro Manila | Observer | After an interview with a member of staff from PAGASA, the researcher was invited to attend this presentation of flood modelling for the Marikina River (the watershed that often causes flooding in Manila). Whilst not directly related to the research, the researcher learned about the current scientific interest in flooding in Manila, interpreted as being a response to the 2009 flooding. |
| *Case Study for Disaster Risk Reduction and Management in Metro Manila: Research Presentation* | 19/10/2012 | Christian Aid/Ateneo De Manila University | Quezon City, Metro Manila | Observer | Opportunity to observe the dynamics between academic scientists, the Manila Observatory and government technical agencies. |

| | | | | | |
|---|---|---|---|---|---|
| *A forum on Child-Centered Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA)* | 16 - 17/10/2012 | The United Nations Children's Fund | Intramuros, Manila | Observer | The Orientation Workshop on Child-Centered Disaster Risk Reduction (CCDRR) aimed to enhance the knowledge of civil society organizations and other stakeholders on what CCDRR is so that future efforts and plans on DRR could further integrate the engagement of children. The researcher was invited to attended by one of her interviewees. She was primarily an observer but met with NGO stakeholders and made opportunities for interviews with NGOs. |

## Appendix B: Interview guide for interviews in Studies A and B

Interview questions, illustrating the key lines of enquiry and the questions asked (some of which were used as prompts).

Background

a. Job title
b. Main responsibilities (v. briefly)
c. How long in the organisation.
d. Previous jobs (this and other organisations).
e. Technical expertise, background, training.

DRR/CCA

1. Could you please give me a brief history of DRR (and CCA) in your organisation?
2. Is there any overlap between DRR and CCA?

Toolkit adoption and application

3. Could you give me an overview of the tools or methods you use for (hazard, vulnerability and) risk assessment? For CCA?
4. Were these developed by other organisations? Why were these adopted?
5. How have these assessments changed over time?
6. What is the scale of assessments? Used to identify hotspots/high risk?
7. What environment are these used in: rural and/or urban?

Tool development

1. What would you say the drivers are (top-down/ bottom-up) that lead to the development of a tool(s) such as this?
2. Are tools designed for a specific purpose/issue?
3. Expertise pulled/external consultations?
4. External funding?

Process for assessing hazards, vulnerability and risk

5. How do you use this tool for hazard assessments and vulnerability assessments?
6. Who uses the tool?
7. Do they consider multi-hazard environments?

8. What information is important to include?
9. Where/ who is the source of information on hazards?
10. Would these ever involve hazard experts or scientists – anyone like that?
11. Are community members seen as the best source on information on hazards?
    a. Managing scientific v. local info conflict?
12. Is there a method for prioritising hazards?
13. What are the outputs of these assessments and what is the information (outputs) used for?
14. Are/ how often are these repeated?

Capacity to use tools

15. What training is given to users of the tool?
16. Have you had feedback/what is your feedback on experiences of using tools?

Effectiveness

17. How do you evaluate the effectiveness of hazard assessment tools? Pilots?
18. How long must the project run before an evaluation of its effectiveness can be made?

Close

19. Can science help in implementing DRR?

## Appendix C: Case study interview guides for scientists and local government, for NGOs and for local communities

The following interview guides acted as a prompt for the interviewer and were adapted depending upon the progression of the interview. The aim was for the participant to express their views with minimal prompting from the interviewee.

### Interview guide for scientists and local government

Personal details

- Role and background

History/experience of event

- In your own words, please describe to me the disaster which occurred on 30th November 2006 (and your involvement in this event)
  - How long it lasted for, hazards, amount of rainfall, etc.
  - Events that led up to it
- Was the area you work in mostly affected by the typhoon, lahars or both?
  - Combined effect or one more dominant?
  - What hazards were most damaging?
- What was the reason for the occurrence of lahars?
  - What was the trigger?
  - What were the causes? Previous disasters; human activity; previous rainfall; role of Milenyo
  - Did the most recent eruption (2006) influence the occurrence and paths taken by the lahars?
- Why was there the observed spatial distribution of lahars and the number of lahars?
  - Were the flows all the same – speed, onset etc.? What were their characteristics?
- What was the impact?
  - Where was it focused?
  - What was the exposure and vulnerability?

- Why were these areas hit and not others?
- Did you/your organisation know that these areas were at risk?

- Why was the disaster so devastating?
  - What were the characteristics of lahars?
  - Were preparedness and warnings more focused upon typhoon? Was there a lack of consideration of lahar risk?
  - Mitigation: what was the role of the dikes? Did they help?
  - Warning: was a warning issued?
  - Evacuation: did people evacuate? Was there complacency or a lack of understanding? Typhoon Milenyo? Need for better communication?
  - What level of communication and understanding of volcanic hazard (beyond eruptions) exists?
  - Who were most affected – the most poor, vulnerable?
- Were [insert other groups] aware of the risk?
  - Communities affected [were they still recovering from typhoon Milenyo or complacent?]
  - Emergency responders
  - Local government

Anticipation of the event

- Adequacy of slope instability risk assessments:
  - Were the areas affected identified in previous lahar risk assessments?
  - When was the last lahar risk assessment carried out prior to this disaster?
  - How was this assessed? Inclusion of typhoon trigger?
  - Did the assessments identify the areas subsequently affected by the Reming lahar?
  - Were these assessments communicated/utilised?
- Have methods of assessing hazard risk changed since this disaster?
  - Have they been updated since? [influence of compounding hazards]
- Was there anything unexpected about this disaster? (i.e. it's trigger/lag time/impact)
- Have there been previous lahars of this size?
  - Rainfall triggered? During eruptions?
  - Are the same areas affected?

Learning from this event

- Has anything changed in the way you work since this event?
    - What did you learn as an organisation?
- What measures have you put in place to prevent a similar disaster happening again?
    - E.g. a full assessment of hazard risk, relocation, monitoring by the community?
    - Do these measures include the threat of other hazards?
    - Is the emphasis upon the lahar or the triggering hazard?

Understanding and perceptions of the event/hazard

- What are the hazards that affect this area?
- What is the typical mechanism of failure of slopes?
    - Tend to be debris flows? Can other types of landslide occur?
- How is the incidence of lahars affected by the occurrence of other hazards? In terms of:
    - Susceptibility
    - Trigger
        - Always rainfall and always immediately after? Intensity/magnitude?
        - Earthquake? How strong?
        - Volcanic eruption? Strength and type?
- How frequently do [damaging] lahars occur? [and any other types of mass movement]
    - Typical time of occurrence?
    - Has there been a change in the number and/or impact of lahars?
    - Communities at risk/responders associate with volcano or typhoon – prior to Reming and now since?
- Which areas tend to be affected?
    - Does it vary?
    - Why do people stay?
    - History of impact?
- Is your assessment of hazard or risk?
- What knowledge is it based upon?
    - Science – academia or government?
    - Community knowledge?
- Are trigger hazards included?
- Are communities more concerned during periods of heavy rainfall since Reming?

- Do you implement scenario planning or probabilistic assessments?
    - Might these help?
    - How do these bring in multi-hazards?
- Is the risk of typhoon greater, less or the same since Reming?
- Do you update hazard assessments?
    - After every disaster?
    - Just communicate that situation could have changed?

Extra: NGO-scientists engagement:

- Have you ever worked with NGOs and on what type of projects?

**Interview guide for NGOs**

Personal details

- Role and background

Experience of event

- In your own words, please describe to me the disaster which occurred on 30th November 2006 [or your involvement]
    - How long it lasted for, hazards – amount of rainfall, etc.
    - Describe events that led up to it.
    - Describe as multi-hazard event?
- Was the area you work in mostly affected by the typhoon, lahars, or both?
    - Combined effect or one more dominant?
    - What hazards were most damaging?
- What was the reason for the occurrence of the lahars?
    - What was the trigger?
    - What were the causes? Previous disasters; human activity; previous rainfall; role of Milenyo
    - Did the most recent eruption (2006) influence the occurrence and paths taken by the lahars?
- Why was there the observed spatial distribution of lahars and the number of lahars?

    - Were the flows all the same – speed, onset etc.? What were their characteristics?
- What was the impact?
    - Where was it focused?
    - What was the exposure and vulnerability?
    - Why were these areas hit and not others?
    - Did you/your organisation know that these areas were at risk?
- Why was the disaster so devastating?
    - What were the characteristics of lahars?
    - Were preparedness and warnings more focused upon typhoon? Was there a lack of consideration of lahar risk?
    - Mitigation: what was the role of the dikes? Did they help?
    - Warning: was a warning issued? Did you/communities receive it?
    - Evacuation: did people evacuate? Was there complacency or a lack of understanding? Typhoon Milenyo? Need for better communication?
    - What level of communication and understanding of volcanic hazard (beyond eruptions) exists?
    - Who were most affected – the most poor, vulnerable?
- Were [insert other groups] aware of the risk?
    - Communities affected [were they still recovering from typhoon Milenyo or complacent?]
    - Emergency responders
    - Local government

Anticipation of the event

- Were you/your organisation aware of the risk from lahars?
    - Did the event come as a surprise?
    - Was the risk from lahars communicated to you/communities?
    - Had your communities conducted risk assessments? (PHVCAs)
    - Was the risk assessment helpful/adequate? Highlight areas affected or miss some out?
    - Did it include the fact that lahar could be triggered by eruption and typhoon? [were lahars included in your/others assessment of typhoon hazard?]
    - How could it have been improved?

    - Have they been updated? Methods changed?
- Have methods of assessing hazard risk changed since this disaster?
    - Have they been updated since? [influence of compounding hazards]
- Was there anything unexpected about this disaster? (i.e. it's trigger/lag time/impact)
- Have there been previous lahars of this size?
    - Rainfall triggered? During eruptions?
    - Are the same areas affected?

Learning from this event

- Has anything changed in the way you work since this event?
    - What did you learn as an organisation?
- What measures have you put in place to prevent a similar disaster happening again?
    - E.g. a full assessment of hazard risk, relocation, monitoring by the community?
    - Do these measures include the threat of other hazards?
    - Is the emphasis upon the lahar or the triggering hazard?

Understanding and perceptions of the event/hazard

- What are the hazards that affect this area?
- What is the typical mechanism of failure of slopes?
    - Tend to be debris flows? Can other types of landslide occur?
- How is the incidence of lahars affected by the occurrence of other hazards? In terms of:
    - Susceptibility
    - Trigger
        - Always rainfall and always immediately after? Intensity/magnitude?
        - Earthquake? How strong?
        - Volcanic eruption? Strength and type?
- How frequently do [damaging] lahars occur? [and any other types of mass movement]
    - Typical time of occurrence?
    - Has there been a change in the number and/or impact of lahars?
    - Communities at risk/responders associate with volcano or typhoon – prior to Reming and now since?
- Which areas tend to be affected?
    - Does it vary?

    - Why do people stay?
    - History of impact?
- Is your assessment of hazard or risk?
    - Science – academia or government? Can you go to them for advice? Do you use scientific information? Are the scientists willing to share?
    - Community knowledge?
- Are you/communities more, or less, concerned about lahars after periods of heavy rainfall since the 2006?
- Is the risk of typhoon greater, less or the same since Reming?
- Do the community update hazard assessments?
    - After every disaster?

Extra: NGO-scientists engagement:

- Have you ever worked with scientists and on what type of projects?

**Interview guide for communities**

- Personal details: name, age, marital status, number of children, occupation and partners' occupation, and length of time in current Barangay
- Can you please describe what happened during typhoon Reming?
    - When did is start?
    - What time did it stop?
    - How did it affect you?
    - Was there strong wind? Heavy rain? Flooding?
    - Can you describe the lahar (speed, materials, destruction)
    - Had it been raining much in the days and weeks beforehand?
    - What was the effect from earlier typhoons, e.g. Milenyo? Damage? Did they bring lahars?
    - Why did Reming bring lahars?
    - Had there been any other disasters in 2006?
- Warning and preparedness
    - Did you receive a warning?
    - How did you receive it and who from?

- What did you do after receiving the warning?
- As what time did you receive it?
- What did it tell you? Anything about rain/flooding/lahar?
- Were you monitoring anything? Changes in animal behaviour? Rain gauges? River levels?
- How did you prepare?
- Did you evacuate? Why? When?
- Did you know what might happen if you stayed?

- Experience and learning
  - Had you experienced typhoons before Reming?
  - How did these compare?
  - Have there been lahars here before?
  - What made Reming different/unexpected?
  - Are do you worry more/less/the same about typhoon/lahars since Reming?
  - What other hazards affect this area?
  - Which one are you most worried about?
  - When did the volcano last erupt?
  - Were there lahars?
  - Does anyone provide you with information on these hazards and how to prepare? Does it help?
  - Have you done hazard mapping? Before/after Reming?
- Current initiatives and risk perception
  - Is there any monitoring of hazards in the community? E.g. rainfall?
  - Since Reming, have you made any changes to the way you prepare for typhoons?
  - How important is preparing for disasters compared with day to day life?
  - How worries are you about disasters compared with day to day life?
  - Are there any actions which could be taken to make you feel safer?
  - Would you evacuate?
  - Would you relocate?
  - How do you feel about pre-emptive evacuation and relocation?

## Appendix D: Reflexive 'diary' extracts from the research

The following extracts outline my reflexive stance in the EngD research:

March 2014:

*Up until my Masters dissertation, I had never utilised nor rigorously studied the philosophies and methodologies of social science research. My interests and, consequently, training had focused upon the natural and physical sciences owing to interest in natural hazards. This interest made me a suitable candidate for this research, owing to the fact that its remit was natural hazard (rather than risk) assessment. However, it quickly became apparent to me that there was a need to understand the context of the problem from those involved and, as such, I adopted a qualitative approach to the majority of this research. I have always regarded the value of the scientific method in terms of its principles of rigour and falsification and thus adjusting to qualitative research, which has highly contested theoretical underpinnings and lacks clarity in terms of validating the research, was daunting. Undoubtedly my initial scepticism of qualitative research will have influenced my approach. Furthermore, conducting interviews was largely beyond my comfort zone and some of this apprehension may have influenced my conduct of interviews. In admitting these influences, however, I was able to learn from and adjust my approaches so as to reduce their influence upon subsequent interviews. These influences were also in the forefront of my mind during data analysis, ensuring that I had an open view to the identification of key themes from the interview findings.*

November 2013:

*Being a young, white, British and female researcher meant that it was difficult not to feel like an outsider in the Philippines. I was certainly a curious sight in the eyes of the interviewee as* *(experienced both during this and the previous trip to the Philippines) participants were quite shocked when they discovered I was travelling alone. My experience of Filipinos is of a very welcoming and hospitable people, so (despite my obvious differences) there were only a couple of times when I perceived that the interviewee was feeling that I was imposing on their time.*

*My being an outsider appeared to influence interviewees' ability to be totally honest with me: few were willing to criticise with true conviction, especially across government departments. However, the international NGOs tended to be more open with their criticism of other stakeholders and some of the scientists were also willing to open up to me about their frustrations regarding the typhoon Reming disaster and beyond. The least open with their criticism tended to be the local government representatives. I realised that it was my influence, and not just a cultural tendency not to criticise, when I observed some of the open criticism between academics and government scientists during my observations (see Appendix A).*

*It was difficult not to perceive that some interviewees were regarding the interview questions as a test, especially when I asked the more obvious questions regarding the event. Indeed, one or two interviewees answered in such a way that it sounded as though they were trying to reduce my ignorance. This was most likely due to my being an outsider and unfortunately it contributed to the persistence of one NGO interpreter to try to 'educate' me rather than allow the community to answer.*

*I felt particularly conspicuous when I visited the communities. I was treated like a celebrity with children following me as I made my visits around the community. In spite of my lack of blonde hair, the children in Barangay Tandarora called me 'Barbie' and when it came to the group photo the women were keen to stand next to me. I also realised that my being there was of greater significance than my research alone; one local NGO told me that the community enjoy the visits and actually get jealous when foreign visitors are taken to other barangays instead of their own.*

*I was also conscious of my relative wealth compared to those I was interviewing; a particularly uncomfortable moment was when a community member asked me on the local Jeepney*[1] *to Anislag and, thus, in front of about 30 others, how much it cost me to fly to the Philippines. I was honest, but could not help but feel that it created an air of separation between us thereafter.*

*It was only after the process that I realised that my style of interview altered depending on the purpose of the meeting and who I was interviewing. At times this was natural – I had met with some of the participants to I unconsciously adopted a more conversational approach to the interview. Other interviews were more formal. This appears to be an artefact of the ease at which some interviewees made me feel; Filipinos have a strong sense of humour and it was not uncommon to share a joke during the interview. One memorable example came from the women interviewed in Barangay Anislag who, on reflecting upon the aftermath of Typhoon Reming, noted that they lost everything, even 'panties!'*

[1] A Jeepney is a local bus.

## Appendix E: Information Sheets and Consent forms

This appendix includes the information sheet and consent forms used for both parts of the research. The first two forms were for the interviews conducted with NGOs and humanitarian and development practitioners in the UK and Philippines regarding NGO methods for hazard assessment. The final four forms were utilised for the purpose of the case study research (there is a different information sheet for communities and DRR stakeholders).

## Part 1 (Studies A and B)

### Information Sheet for NGO participants in Research Studies

### Title of Project: Multi-hazard assessment for building sustainable and resilient communities in the Philippines

**Researcher:**

Melanie Duncan
Aon Benfield UCL Hazard Reseach Centre
University College London
Gower Street
London WC1E 6BT
UK

You are invited to participate in the research project: multi-hazard assessment for building sutainable and resilient communities in the Philippines. Details of the project and its proposed outcomes are given below. Please ask if anything is not clear or if you would like more information.

**Details of study**

**What is the purpose of this research?**

The aim of this research is to adapt/ develop methods for multi-hazard (including climate change) assessment which can be used by NGOs and their partners to inform decision-making based on both scientific analysis and local and indigenous knowledge.

The benefits of this research are for the wider NGO community.

**Who is organising this research?**

This study is being conducted by me under the supervision of Dr Stephen Edwards, Dr John Twigg, Dr Christopher Kilburn and Dr Tiziana Rossetto at University College London, and Dr Jessica Mercer and Dr Mike Edwards at CAFOD. It forms part of my doctoral research.

**What does this study involve?**

**Background**: There is a general consensus that natural hazards and climate change will have increasing impacts in the future. That said, the timescales, magnitudes and interactions of these impacts are poorly constrained and this uncertainty limits the effectiveness of strategies for disaster risk reduction and climate change adaptation. One of the greatest challenges facing these strategies, and their future development, is their need to rigorously assess and quantify the impacts of natural events and climate change in complex multi-hazard environments, and for this knowledge to then be used by decision-makers to devise and implement responsible practical solutions.

This research is in partnership with CAFOD (working closely with Jessica Mercer and Mike Edwards) and my aim is to develop/adapt methods for scientific multi-hazard assessment to incorporate climate change and inputs from local knowledge. The developed method will be useable by NGOs and their partners and aims to be of benefit to the wider NGO community. Such assessments will inform decision-making for building community resilience and should fit well into development programmes and humanitarian work.

As part of my PhD research, I conducted a study involving interviews with a variety of NGOs in the UK and some of their partners, in order to determine how NGOs assess hazards and acquire information on hazards, and how this information is used to reduce risk and adapt to climate change. The next part of the research involves interviewing those on the ground who have experience in implementing the tools for DRR/CCA.

The primary objective of this trip to the Philippines is to visit a variety of field sites and speak to key informants with regard to deciding where to base the PhD field work and to interview NGOs with experience of implementing hazard assessments for DRR/CCA. Note, the final decision as to where to carry out the field work may be made several weeks/ months after the scoping exercise depending on how much further analysis and correspondence is required with key informants.

**Secondary objectives:**

a. To establish relationships with key stakeholders.
b. To determine **potential** location and living arrangement for longer term fieldwork placement
c. Identify security issues for discussion upon return
d. To gain an understanding of the context and the environment within which I will work
e. Establish where other agencies are working

**Where will the meetings/ interviews take place?**

In agreeing to take part, I shall arrange a time around your work schedule for me to come to your office and conduct the interview.

**What will happen during the interviews?**

If you are happy for me to do so, I will also record the interviews. This is to ensure that I don't miss any information during the interview. A copy of your interview recording can be made for you and you will be required to sign a consent form. I will be asking questions related to your work on DRR and/or climate change adaptation.

All data will be collected and stored in accordance with the Data Protection Act 1998.

**What happens to the information gathered from the interviews?**

The interviews will form a report on NGO tools and assessments and all participants will be kept anonymous. This report may also form part of my final PhD thesis. You will be provided with a copy of the report.

## Consent Form for NGOs in Research Studies

## Title of Project: Multi-hazard assessment for building sustainable and resilient communities in the Philippines

**Researcher:**

Melanie Duncan
Aon Benfield UCL Hazard Reseach Centre
University College London
Gower Street
London WC1E 6BT
UK

If you have any questions arising from the Information Sheet or the explanation already given to you, please ask me before you consent to participate in this research. You will be given a copy of this Consent Form to keep for your reference.

**Participant's Statement:**

**Please tick the following that apply:**

- ☐ I agree that the research project named above has been explained to me to my satisfaction, I have read the information sheet, and I agree to take part in this study.
- ☐ I understand that if I decide at any time that I no longer wish to take part in this research, I can notify Melanie Duncan and withdraw immediately.
- ☐ I understand that my participation in this research will be kept anonymous.
- ☐ I am happy for this interview to be recorded and am aware of and consent to, any use Melanie Duncan intends to make of the recordings during and after the research.
- ☐ I understand that information I have submitted will be included in a report and I will be sent a copy. I shall remain anonymous and reference will only be made to my organisation.
- ☐ I agree that the information I provide may be used by others for future research.

Name (please print): ____________________________

Signature: _____________________________________ Date: ________________

Researcher's signature: ________________________ Date: ________________

## Part two (Study C)

### Information Sheet for DRR practitioners and experts in Research Studies

## Title of Project: Multi-hazard assessment for building resilient communities in the Philippines

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 2192/001.

**Researcher:**

Melanie Duncan
Aon Benfield UCL Hazard Centre
University College London
Gower Street
London WC1E 6BT
UK

You are invited to participate in the research project: multi-hazard assessment for building resilient communities in the Philippines. Details of the project and its proposed outcomes are given below.

**Details of study**

**What is the purpose of this research?**

The aim of this research is to develop a method for multi-hazard assessment which can be used by NGOs and their partners to inform decision-making based on both scientific analysis and local and indigenous knowledge, and to field test that method in the Philippines.

**Who is organising this research?**

This study is being conducted by me under the supervision of Dr Stephen Edwards, Dr Christopher Kilburn, and Dr John Twigg at University College London (UCL), and Dr Kate Crowley at the Catholic Agency for Overseas Development (CAFOD).

**What does this study involve?**

**Background**: One of the greatest challenges facing DRR strategies is the need to rigorously assess and quantify the impacts of natural events in complex multi-hazard environments, and for this knowledge to then be used by decision-makers to devise and implement responsible practical solutions. Landslides constitute both a primary and secondary hazard as well as a cause of subsequent hazards and are thus central to the understanding of multi-hazard risk.

The objective of this trip to the Philippines is to visit a variety of field sites where landslides have occurred in recent years and speak to key informants about their experience of the landslide and their perceptions of landslide and other hazard risks. I will also be field testing a tool for assessing multi-hazard risk, using the example of landslides.

**Benefits**: This research is in partnership with CAFOD and my aim is to develop methods for scientific multi-hazard assessment to assess the interactions between hazards, build scenarios of these interactions, whilst incorporating inputs from local knowledge. The developed method will be useable by NGOs and their partners and thus should be of benefit to the wider NGO community since such assessments will inform decision-making for building community resilience and should fit well into development programmes and humanitarian work.

**Where will the meetings/interviews take place?**

In agreeing to take part, I shall arrange a time around your work schedule for me to come to your office and conduct the interview.

**What will happen during the interviews?**

I will be asking questions related to your work on DRR in the context of the 30th November 2006 Mt Mayon lahars and future risk of lahars and other multi-hazards in this area. If you are happy for me to do so, I will also record the interviews. This is to ensure that I don't miss any information during the interview. A copy of your interview recording can be made for you and you will be required to sign a consent form.

**What happens to the information gathered from the interviews?**

The information you provide will be included in my PhD thesis, and you have the option to remain anonymous within this report. I am happy to provide you with a copy of the completed thesis if you wish. The information you provide may also be used to inform additional reports and published papers. The information may also be shared with my supervisors at UCL and CAFOD (mentioned above) for the purposes of helping me write my PhD thesis.

The information you provide will assist NGOs, like CAFOD, in their understanding and assessment of multi-hazard risk so that they are better able to help reduce the risk from disasters.

Please discuss the information above with others if you wish or ask me if there is anything that is not clear or if you would like more information.

It is up to you to decide whether to take part or not; choosing not to take part will not disadvantage you in any way. If you do decide to take part you are still free to withdraw at any time and without giving a reason.

**All data will be collected and stored in accordance with the UK Data Protection Act 1998.**

## Information Sheet for community participants in Research Studies

## Title of Project: Multi-hazard assessment for building resilient communities in the Philippines

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 2192/001.

**Researcher:**

Melanie Duncan
Aon Benfield UCL Hazard Centre
University College London
Gower Street
London WC1E 6BT
UK

You are invited to participate in the research project: multi-hazard assessment for building resilient communities in the Philippines. Details of the project and its proposed outcomes are given below.

**Details of study**

**What is the purpose of this research?**

The aim of this research is to develop a method for multi-hazard assessment which can be used by NGOs and their partners to inform decision-making based on both scientific analysis and local and indigenous knowledge, and to field test that method in the Philippines.

**Who is organising this research?**

This study is being conducted by me under the supervision of Dr Stephen Edwards, Dr Christopher Kilburn, and Dr John Twigg at University College London (UCL), and Dr Kate Crowley at the Catholic Agency for Overseas Development (CAFOD).

**What does this study involve?**

I am from University College London in the United Kingdom and am working with a UK based NGO called the Catholic Agency for Overseas Development (CAFOD) and I am visiting the Philippines in order to pilot a method for assessing multi-hazards using the example of landslide risk. I am visiting areas where landslides have occurred in recent years in order to interview people with experience of the landslide and their perceptions of landslide and other hazard risks.

**Where will the meetings/interviews take place?**

In agreeing to take part, I shall arrange a time and place that is convenient for you.

**What will happen during the interviews?**

If you are happy for me to do so, I will ask you a series of questions about your experience of the 30th November 2006 Mt Mayon lahars and your knowledge of lahar and multi-hazard risk, as well as some personal details including your name, age, occupation, marital status, whether you have children, and how long you have lived in this area. If you feel uncomfortable with answering any of the questions please let me know.

If you are happy for me to do so, I will record the interviews. This is to ensure that I don't miss any information during the interview. A copy of your interview recording or transcript can be made for you and you will be required to sign a consent form.

**Benefits**: the results from this research should help to reduce disaster risk from multiple hazards.

**What happens to the information gathered from the interviews?**

The information you provide will be included in my PhD thesis, and you have the option to remain anonymous within this report. I am happy to provide you with a copy of the completed thesis if you wish. The information you provide may also be used to inform additional reports and published papers. The information may also be shared with my supervisors at UCL and CAFOD (mentioned above) for the purposes of helping me write my PhD thesis.

The information you provide will assist NGOs, like CAFOD, in their understanding and assessment of multi-hazard risk so that they are better able to help reduce the risk from disasters.

Please discuss the information above with others if you wish or ask us if there is anything that is not clear or if you would like more information.

It is up to you to decide whether to take part or not; choosing not to take part will not disadvantage you in any way. If you do decide to take part you are still free to withdraw at any time and without giving a reason.

**All data will be collected and stored in accordance with the UK Data Protection Act 1998.**

## Informed consent form for participants in Research Studies

## Title of Project: Multi-hazard assessment for building resilient communities in the Philippines

This study has been approved by the UCL Research Ethics Committee (Project ID number): 2192/001

**Researcher:**

Melanie Duncan
Aon Benfield UCL Hazard Centre
University College London
Gower Street
London WC1E 6BT
UK

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or the explanation already given to you, please ask me before you consent to participate in this research. You will be given a copy of this Consent Form to keep for your reference.

**Participant's Statement:**

I ______________________

- agree that the research project named above has been explained to me to my satisfaction, I have read the information sheet, and I agree to take part in this study.
- understand that if I decide at any time that I no longer wish to take part in this research, I can notify Melanie Duncan and withdraw immediately.
- am happy for this interview to be recorded and am aware of and consent to, the use of this recording for the purpose of this and any future research.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study.
- understand that any information I have submitted will be included in Melanie Duncan's PhD thesis and I will be sent a copy.
- understand that any data recorded will be handled in accordance with the provisions of the United Kingdom's Data Protection Act 1998.
- [Please delete as appropriate] wish/do not wish to remain anonymous in Melanie Duncan's thesis and any reports regarding this research.
- agree that the information I provide may be used by others for future research.

Signature: ___________________________________ Date: ________________

Researcher's signature: ______________________ Date: ________________

## Appendix: F Historical eruptions of Mayon volcano

The following table presents the historical eruptions (1616-2010) of Mayon volcano taken from a variety of sources indicated in the far right column. The abbreviations used below are as follows: Y = year; M = month; D = day; VEI = volcanic explosivity index; AF = ashfall; TF = tephra fall; PF = pyroclastic flow; LF = lava flow; L = lahar; RS = rock slide; VL = volcanic lightening and EQ = earthquake (Ramos-Villarta et al., 1985).

| **Start date** | | | **End date** | | | **Type of Eruption** | **VEI** | **Type of Activity** | | | | **Associated Activity** | | | | **Places Affected** | **Impact** | **Sources** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Y** | **M** | **D** | **Y** | **M** | **D** | | | **AF** | **TF** | **PF** | **LF** | **L** | **RS** | **VL** | **EQ** | | | |
| 3100 BCE ± 300 years | | | | | | | | | | | | | | | | | | GVP (2013) |
| 470 ± 75 years | | | | | | | | | | | | | | | | | | GVP (2013) |
| 1616 | 2 | 19 | 1616 | 2 | 23 | | 3 | X | X | X | X | ? | | | X | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1766 | 7 | 20 | 1766 | 7 | 25 | VULC | 3 | X | | X | X | X | | | | AF, PF and LF - East | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1800 | 10 | 30 | 1800 | 10 | 31 | VULC | 2 | X | X | X | | | | | | Cagsua, Budiao, etc. | Fatality details unknown. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1814 | 2 | 1 | 1814 | 2 | 1 | PLIN | 4 | X | X | X | | X | X | X | | PF - southern slopes Camalig, Cagsaua, Budio, Guinobatan, half of Albay; L - Cagsaua & Budiao; AF/L? - Ligao, Guinobatan, Libog (St. Domingo), Tabaco & Tiwi | 1200 fatalities | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1827 | 6 | | 1828 | 2 | | VULC | 2 | X | X | X | | X | | X | X | L - Camalig | | Ramos-Villarta et al. (1985) |
| 1834 | 5(?) | ? | 1835 | ? | ? | VULC | 3 | X | X | X? | X | X | X | | | | | Ramos-Villarta et al. (1985); PHIVOLCS (2013) |
| 1839 | | | | | | | 2 | X | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1845 | 1 | 21 (+/- 1) | 1845 | 1 | 21 (or 30 +/- 1) | VULC | 3 | X | X | X | | X | X | | | AF - southwest Camalig, Guinobatan & Ligao | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1846 | 5 | 11 | 1846 | 5 | 11 | VULC | 3 | X | | X? | | X? | | | | Camalig - 12 cm ash. | | Ramos-Villarta et al. (1985) (discrepancies with PHIVOLCS (2013) data - ?) |
| 1851 | 5 | 26 | 1851 | 6 | ? | | 1 | X | | | | | | | X | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1853 | 7 | 13 | 1853 | 8 | 26 | VULC | 3 | X | | X | | X | | | | PF - Camalig, Guinobatan; L - Ligao, Oas, Polangui; AF - Malilipot, Bacacay, Libog (Sto. Domingo), Guinobatan, Camalig, Albay, Cagsaua. | 33 fatalities (Sapper, Faustino) or 35 (Saderra Maso). Deaths caused by incandescent rocks rolling down from the summit, destroying many houses and their occupants (Faustino). Major lahar 27th July. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1855 | 3 | 22 | ? | ? | ? | | 2 | X | | | X | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1857 | ? | ? | ? | ? | ? | | 2 | X | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1858 | 1 | ? | ? | 12 | ? | SRRM | 2 | X | | X? | X | X | | | X | | Many people died from malnutrition and poor sanitation in the evacuation centres. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1861 | | | | | | | 1 | | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1862 | | | | | | | 2 | X | | | | X | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1868 | 12 | 17 | | | | VULC | 2 | X | X | X | | X | X | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1871 | 12 | 8 | 1872 | 1 | | VULC | 3 | X | X | X | | | X | X | X | PF - S to SE; Albay, Legazpi; AF - Camalig, Guinobatan (SW) | Property damage. Deaths by nuées ardentes. In the "vista" of Boctong, two persons were suffocated and in Buyuan, one was burned. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1872 | 9 | 5 | 1872 | 9 | 9 | | 1 | X | | | X | | X | | | | | Ramos-Villarta et al. (1985); GVP (2013) |
| 1873 | 6 | 20 | 1873 | 7 | 22 | | 2 | X | | | X | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1876 | 4 | | | | | | 1 | X | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1876 | 11 | 26 | | | | | 1 | X | | | | | | | | | | Ramos-Villarta et al. (1985) have the two 1976 events down as separate events in the text, as do the Smithsonian (2013). PHIVOLCS (2013) (2013). |
| 1881 | 7 | 6 | 1882 | 8 | | STRM | 3 | X | | X | X | X | | | | AF - Camalig & Guinobatan; LF - S, SE, & SW slopes | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1885 | 11 | 21 | 1885 | 12 | 2 | | 2 | X | | | X | | | | | LF - SSW, W & SSE slopes | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1886 | 7 | 8 | 1887 | 3 | 10 | STRM | 3 | X | | X | X | X | | | | AF - Camalig, Guinobatan & Libog [Sto. Domingo] | 20-hour ash eruption at end of 9-month eruption deposited 8 cm of ash on roofs in Guinobatan and Libog. Collapse of roofs killed 15. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1888 | 12 | 15 | ? | ? | ? | | 1 | X | | | | | X | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1890 | 9 | 10 | 1890 | 9 | 30 | VULC - STRM | 2 | X | | | X | | | | | LF - threatened Libog [Sto. Domingo] | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1891 | 10 | 3 | 1891 | 12 | 3 | | ? | X | | | X | | | | | LF - S & SW | | Ramos-Villarta et al. (1985); GVP (2013) |
| 1892 | 2 | 3 | 1892 | 2 | 29 | VULC | 2 | X | X | X | X | | X | | | PF - E & SE slopes (PHIVOLCS (2013): Libog [Sto. Domingo] and Camalig) | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1893 | 10 | 4 | 1893 | 10 | 31 | | 1 | X | X | | X | X | X | | X | LF - eastern slopes | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1895 | 7 | 20 | 1895 | 11 | 26 | | 2 | X | | | X | X | X | X | X | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1896 | 8 | 31 | 1896 | 9 | 27 | | 2 | X | | | X | X | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | 6 | 4 | 1897 | 7 | 23 | Strong VULC | 4 | X | X | X | X | X | X | X | X | PF - seashore of Sto. Domingo, barrios of Sto. Nino, San Isidro, San Roque, San Antonio, Sta. Misericordia, Ligao & parts of Bigaa; San Fernando, Legazpi overwhelmed; L - Basud River [Sto. Domingo] ENE, Camalig; AF - Tabaco, Camalig, Libog [Sto. Domingo], Bacacay and Malilipot, Tiwi. | At least 226 causalities were caused by the large pyroclastic flow that destroyed the barrios of Sto. Domingo. Total death toll from 25-27th June estimated to be 350. 1 death at Bulwan caused by lahar (Smithsonian). | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1900 | 3 | 1 | 1900 | 3 | 6 | VULC | 2 | X | X | X | X | X | X | X | X | LF - Legazpi & Libog; AF - Ligao, Guinobatan, Tabaco, Libog [Sto. Domingo] & Camalig | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1902 | | | | | | | 1 | | X | | | X | X | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1928 | 1 | ? | 1928 | 8 | ? | VULC | 3 | X | | X | X | | | | | PF - San Antonio, Malilipot; AF - San Antonio, Tabaco; Amtic, Ligao; TF - Bonga, Bacacay; LF - Libog [Sto. Domingo] | Pyroclastic flows between June 25 and Aug 7 killed at least one. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1938 | 6 | 5 | | | 2 | VULC | 2 | X | | X | X | | | | | Foothill barrios of Legazpi & Libog [Sto. Domingo]; AF - Guinobatan, Ligao, Camalig, Daraga & Tabaco; LF - Sto. Domingo | Fatality details unknown. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1939 | 8 | 21 | 1939 | ? | ? | | 1 | X | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1941 | 9 | 13 | 1941 | ? | ? | | 1 | X | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1943 | ? | ? | 1943 | ? | ? | | 1 | X | | | | | | | | | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1947 | 1 | 8 | 1947 | 2 | ? | VULC | 2 | X | | X | X | | | | | LF - Sto. Domingo; Calbayog, Malilipot; PF - San Vicente, Malilipot; AF - Masarawag, Guinobatan, ankle-deep ash. | Fatality details unknown. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1968 | 4 | 20 | 1968 | 5 | 20 | VULC | 3 | X | | X | X | X | | | | AF - Camalig & Guinobatan [and Legazpi]; LF - Camalig; PF - Tinobran, Quirangay, Miisi, Bonga. | One death by lahar in Aug or Oct, the others during the eruption. Moore and Melson 1969 list at least 6 as of 15 May 1968. | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1978 | 5 | 3 | 1978 | 7 | 4 | STRM | 2 | X | X | | X | | X | | X | LF - Camalig [PHIVOLCS (2013) says ashfall]. | | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 9 | 9 | 1984 | 10 | 6 | VULC | 3 | X | X | X | X | X | X | X | X | LF - Camalig; AF - Sto. Domingo, parts of Legazpi; PF - SE & E; Bonga, Sto. Domingo. | 1 person killed by lahar. Reports of unsanitary conditions in evacuation centres leading to deaths of children GVP, 2013). | Ramos-Villarta et al. (1985); GVP (2013); PHIVOLCS (2013) |
| 1993 | 2 | 2 | 1993 | 4 | 4 | VULC - STRM | 2 | X | X | X | X | X | X | | X | PF - Mabinit, Bonga; AF - Camalig, Sto. Domingo, Legazpi; LF and L confined to gullies. | 77 killed, 5 injured (GVP (2013) quotes 100 injuries). >45,000 persons fled homes following the pyroclastic flow of February 2. 12,000 persons evacuated when Strombolian activity began March 19-21 GVP (2013). | Catane et al. (2005); PHIVOLCS (2013); GVP (2013). |
| 1999 | 6 | 22 | 2000 | 3 | 19 | STRM - VULC | 3 | X | | X | X | | X | | X | AF - Guinobatan, Ligao, Camalig; LF and PF confined to gullies. | | Recorded by BGVN (GVP, 2013). PHIVOLCS (2013) |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 1 | 8/9 | 2001 | 8 | 8 | STRM - VULC | 3 | X | X | X | X | X | X | | X | PF - Bonga, Basud, Miisi, Anoling; AF - Camalig, Guinobatan, Daraga, Legazpi, Sto. Domingo; LF and L confined to gullies. | | Catane et al. (2005) |
| 2003 | 3 | 17 | 2003 | 5 | 14 | | 2 | X | | | | | | | | | | PHIVOLCS (2013); GVP (2013). |
| 2004 | 7 | 21 | 2004 | 7 | 21 | | 1 | X | | | | | | | | | | GVP (2013) |
| 2005 | 8 | 17 | ? | ? | ? | | 0? | | | | | | | | | | | Unconfirmed - not in PHIVOLCS (2013) online catalogue. GVP (2013) |
| 2006 | 2 | 21 | 2006 | 2 | 23 | | 1 | X | | | | | | | X | | | Unconfirmed - not in PHIVOLCS (2013) online catalogue.; GVP (2013) |
| 2006 | 7 | 14 [13?] | 2006 | 10 | 1 | | 1 | X | | X | X | | | | | LF - Bonga valley, Mabinit channel | 50,000 people evacuated. | GVP (2013) |
| 2008 | 8 | 10 | 2008 | 8 | 10 | | 1 | X | | | | | | | | | | GVP (2013) |
| 2009 | 9 | 15 | 2010 | 1 | ? | | 2 | X | | X | X | | X | | | | More than 47,000 people from 30 villages were in evacuation centres across Albay province. | GVP (2013) |

## Appendix G: Community interview participants

The following tables provide background to the communities interviewed in each of the municipalities. In the context of the group interviews, those participants highlighted in bold represent those who contributed the most to the interview.

**Municipality: Camalig**

**Barangay Sua**

| *Barangay* | *Date of interview* | *Name* | *Sex* | *Age* | *Job* | *Spouse's job* | *Length of time living in current barangay* | *Recorded* | *Consent from signed* | *Type of interview* |
|---|---|---|---|---|---|---|---|---|---|---|
| *Sua* | 29/10/2012 | Perla | F | 56 | Barangay secretary and Disaster Preparedness Committee presiding officer | n/a | Since birth | Y | Y | One to one |

**Municipality: Daraga**

**Barangays Binitayan and Tagas (**residents of the latter barangay are now residing in Barangay Anislag)

| ***Barangay*** | ***Date of interview*** | ***Name*** | ***Sex*** | ***Age*** | ***Job*** | ***Spouse's job*** | ***Length of time living in current barangay*** | ***Recorded*** | ***Consent from signed*** | ***Type of interview*** |
|---|---|---|---|---|---|---|---|---|---|---|
| *Binitayan* | 26/10/2012 | Imelda | F | 48 | Food vendor | [Did not state] | 25 | Y | Y | Group |
| | | **Gloria** | F | 53 | Barangay kagawad (councillor) | labourer | | Y | Y | |
| | | **Rowena** | F | 36 | Housewife | Driver | 12 | Y | Y | |
| | | Laticia | F | 56 | [Did not state] | Barangay Tanod (police) | 4 | Y | Y | |
| | | **Gemma** | F | 42 | Housewife | Driver | 35 | Y | Y | |
| | | **Marcibel** | F | 46 | Housewife | Driver | 18 | Y | Y | |
| | | **Jezzabell** | F | 31 | Housewife | Plumber | 18 | Y | Y | |
| | | Trinidad | F | 54 | Wala – None | [Did not state] | [Did not state] | Y | Y | |
| | | Sylvia | F | 55 | Housewife | [Did not state] | [Did not state] | Y | Y | |
| | | Jenifer | F | [Did not state] | Food vendor | [Did not state] | 35 | Y | Y | |
| | | Elizabeth | F | 33 | Housewife | Vendor | [Did not state] | Y | Y | |
| *Anislag (formally Tagas)* | 26/10/2012 | Jacqueline | F | 32 | None | [Did not state] | [Did not state] | Y | Y | Group |
| | | Norma | F | 46 | None | [Did not state] | [Did not state] | Y | Y | Group |
| | | **Rosemarie** | F | 47 | Self-employed | [Did not state] | 5 (7 resettlement site) | Y | Y | Group |
| | | Dominga | F | 64 | Self-employed | [Did not state] | 5 (7 resettlement site) | Y | Y | Group |
| | | **Nita** | F | 38 | Housewife | [Did not state] | 5 (7 resettlement | Y | Y | Group |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | site) | | | |
| | | **Lolita** | F | 54 | Housewife and barangay health water (and psychologist?) | [Did not state] | 18 (6 resettlement site) | Y | Y | Group |

**Municipality: Guinobatan**

**Barangay: Tandarora**

| ***Barangay*** | ***Date of interview*** | ***Name*** | ***Sex*** | ***Age*** | ***Job*** | ***Spouse's job*** | ***Length of time living in current barangay*** | ***Recorded*** | ***Consent from signed*** | ***Type of interview*** |
|---|---|---|---|---|---|---|---|---|---|---|
| Tandarora | 25/10/2012 | Maria | F | 76 | Housewife | Farmer | 12 | Y | Y | One to one |
| | | **Marivic** | F | 36 | Barangay Kagawad (councillor) | OFW | 34 | Y | Y | Group |
| | | Jimmy | M | 59 | Barangay Kagawad (councillor) | House wife | 44 | Y | N | Group |
| | | **Nilda** | F | 49 | Housewife | Tanod (police)/ farmer | 22 | Y | Y | Group |
| | | **Enemicia** | F | 74 | Housewife | Farmer | 74 | Y | Y | Group |
| | | **Marites** | F | 41 | Barangay captain | PNR employee | 41 | Y | Y | Group |
| | | **Jean** | F | 36 | None | Fish vendor | 36 | Y | Y | Group |
| | | **Marilu** | F | 41 | Housewife | Farmer | 17 | Y | Y | Group |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Gemma | F | 37 | Housewife | Farmer | 9 | Y | Y | Group and one to one |
| | | Monina | F | 49 | Housewife | [Did not state] | 22 | Y | Y | Group |
| | | Lorafe | F | 23 | Housewife | Baker | 4 | Y | Y | Group |
| | | Erma | F | 36 | Housewife | Farmer | 36 | Y | Y | Group |
| | | Francia | F | 53 | Housewife | Farmer | 53 | Y | Y | Group |
| | | **Estrella** | F | 49 | Housewife | [Did not state] | 22 | Y | Y | Group |
| | | Gloria | F | 38 | Housewife | [Did not state] | ? | Y | Y | Group |

## Municipality: Santo Domingo

## Barangay Lidong, San Antonio and San Isidro

| ***Barangay*** | ***Date of interview*** | ***Name*** | ***Sex*** | ***Age*** | ***Job*** | ***Spouse's job*** | ***Length of time living in current barangay*** | ***Recorded*** | ***Consent from signed*** | ***Type of interview*** |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Lidong*** | 22/10/2012 | Leja | F | 29 | [Housewife] | Farmer | Whole life | N | N (LG signed form to confirm oral consent) | One to one |
| | | Group of 10 women | F | late 20s-70s | Handicraft | Factory workers/construction/furniture making/quarrying but the majority are farmers | Always and want to stay | N | N (LG signed form to confirm oral consent) | Group |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Renaldo | M | 63 | Carpenter (recently suffered from a stroke) | Didn't say | Not specified | N | N (LG signed form to confirm oral consent) | Interview with wife |
| | | Mercedes | F | 58 | Didn't say | Carpenter (recently suffered from a stroke) | Not specified | N | N (LG signed form to confirm oral consent) | Interview with husband |
| | | Edraline | M | 38 | Rice farmer | Didn't say | Whole life | | N (LG signed form to confirm oral consent) | One to one |
| ***San Antonio*** | 30/10/2012 | Irma | F | 55 | Housewife | Quarrying | 20 | Y | Y | Interview with husband (below) |
| | | Antonio | M | 59 | Quarryman | House wife | 6 | Y | Y | Interview with wife (above) |
| ***San Isidro*** | 30/10/2012 | Jerry | M | 38 | Unemployed (usually machine operator) - previously worked in Manila | n/a | Since birth | Y | Y | One to one |

**<u>Non-lahar affected community</u>**

**Municipality: Santo Domingo**

**Barangay Salvacion**

| *Barangay* | *Date of interview* | *Name* | *Sex* | *Age* | *Job* | *Spouse's job* | *How long lived in this barangay* | *Recorded* | *Consent from signed* | *Type of interview* |
|---|---|---|---|---|---|---|---|---|---|---|
| Salvacion | 12/10/2012 | Merlinda | F | ? | Shop attendant | Tricycle driver | 15 | N | | One to one |
| | | Myrna | F | 47 | Seamstress | Construction worker/farmer | 25 | N | Y | Group |
| | | Hilda | F | 54 | Seamstress | Farmer | Since birth | N | Y | Group |
| | | Adele | F | 75 | Seamstress | [Did not say] | 60 | N | Y | Group |

## Appendix H: Reming lahars impact on barangays visited in October 2012

The following are specific details from field observations and interviews regarding the damage to their barangays, supplemented with findings from PHIVOLCS reports. Appendix G provides the background details to the residents mentioned below.

**Barangay Lidong, Santo Domingo**

Leja lives next to the river channel. She explained that her home was completely destroyed and that 20 houses were destroyed in this barangay. It was not only homes, but livelihoods that were badly affected, including destroyed rice fields (concurred by the women's group) and loss of chickens. Renaldo and Mercedes described the damage to their home as being caused by the wind, lahar and the flood. They live in a concrete home and only lost their kitchen extension at the back of the home. Edraline's home was similarly constructed to Leja's (bamboo, scrap material) and was - again - completely destroyed. Hyperconcentrated flows and flood deposits of 0.5m and 1m affected this barangay (PHIVOLCS, 2006a).

**Barangay Tandarora, Guinobatan**

The entrance to Tandarora is an obvious marker of the amount of material deposited by the lahar; the arch that marks the entrance to the barangay is several metres shorter than it previously was. There are large (several metres in diameter) boulders scattered about the place and ruins of houses on entry to the barangay. On the road up to Tandarora, there are still ruined homes. I visited the home of Maria (a large concrete house) who told me that there was a 1-1.5 metre depth of lahar surrounding her home which was completely flooded and the kitchen at the back was damaged; the lahars are reported to have deposited 2-4 metres of material (PHIVOLCS., 2007a). According to PHIVOLCS (2007b), the lahars occurred in three sudden episodes, as dark slurry flows fronted with boulders and assorted debris. Maria said they were affected by the flood, the water and the flooding, and the lahar, 'the sand' and the wind. During a meeting with residents in the barangay hall, the women described their husbands going back to the barangay after the typhoon and seeing bodies. Again, they felt the effects of all dimensions of the typhoon: the water, wind and the lahar. Eleven people died in this village and two were unrecovered. Gemma's very light framed house was actually lifted up by the wind. Members of this barangay were (and still are) working with Local NGO B before typhoon Reming. Further downstream along the Maipon-Masarawag Channel the lahar exposures transition to hyperconcentrated streamflow deposits as a consequence of possible debulking of the debris flows (Bornas et al., 2007b).

**Barangay Anislag (formally residents of Barangay Tagas), Daraga**

The women's group said 'the flood' and 'the lahar' destroyed all the houses and their belongings. There was flooding and 0.5 metres of deposition but that the potential for future lahars and avulsion was high and, as such, the residents were relocated (PHIVOLCS, 2006a). Residents evacuated during the event and were unable to change their clothes for four days:

> *'four days no changing of clothes, no panties'* (Lolita)

Whilst this was said in good humour it also reflected how painful this experience was; people were residing in evacuation centres, unable to wash and clean their clothing, which is culturally difficult in the Philippines because cleanliness is observed stringently. After 10 months in the evacuation centre and temporary accommodation they were transferred to Barangay Anislag (the resettlement site) where they described many of the same problems described by (Usamah and Haynes, 2012) including lack of basic services and livelihood options; although there have been recent improvements. After Typhoon Reming, they partnered with Local NGO A as part of their building disaster resilient communities campaign and have since conducted hazard seminars and DRR training.

**Barangay Binitayan, Daraga**

Similarly in Binitayan, the notion of not having clean underwear (and the mixture of jest and distress that surrounds this memory) was shared, however the women emphasised the trauma of this event - loss of relatives, livelihoods, homes, appliances and even panties. Flash flood and lahar were remembered as the hazards that caused greatest damage. Orense and Ikeda (2007) note that it was the lahar that caused the flood; the lahar sediments filled the Yawa River channel causing it to flood nearby. According to PHIVOLCS, Binitayan was buried by debris (PHIVOLCS, 2006b). The interviews were conducted in the home of Gloria Miranda, who described the lahar as reaching the ceiling of the house. The researcher visited this barangay during the scoping visit in 2010 and during that visit and had the opportunity to wander round and observe the damage caused by this event. The residents said that they spent 10 months in the evacuation centre after Reming. After this typhoon, they also partnered with Local NGO A as part of their building disaster resilient communities campaign. They have conducted DRR training including participatory vulnerability and capacity assessments and typhoon tracking.

Binitayan was one of areas worst affected by high discharge and overtopping of the Yawa River. The resulting 2-3 metres deposit is black, massive with clasts consisting of cobbles to boulders in coarse sandy matrix (PHIVOLCS, 2006b).

**Barangay Sua, Camalig**

This barangay is the closest to the volcano with one Purok (6) actually sitting within the 6km permanent danger zone. Perla is a member of the Disaster Preparedness Committee and was so during typhoon Reming. Given her role, she reflected on the barangay as a whole describing three casualties, property damage, homelessness, damaged farms and dead animals as some of the major impacts. Personally, she was affected by heavy rains and wind her, whilst her neighbours (Purok 1) were affected by lahar. Sua was affected by lahar deposition and is at high risk from future lahar as a consequence of possible avulsion and flooding upstream (PHIVOLCS, 2006a). Residents affected by the typhoon spent three months in the evacuation centre. Members of this barangay were (and still are) working with Local NGO B before Typhoon Reming, along with a number of other international NGOs.

**Barangay San Antonio, Santo Domingo**

Irma and Antonio said that they were affected by the lahar but, whilst the roof was blown off their home, the concrete structure remained, however they lost a granddaughter during the disaster. They live along the road perpendicular to the main channel. It was observed from the edge of the channel that boulders of different sizes and the remnants of an earth dike that had a cement veneer one on one side but that had been breached remain. According to PHIVOLCS, San Antonio was affected by hyperconcentrated flow and flood deposition of between 0.5m and 1m (PHIVOLCS, 2006a). During typhoon Reming, 15 residents along the road sheltered in Irma and Antonio's home. They mentioned that they received no assistance with which to repair their home after the lahars.

**Barangay San Isidro, Santo Domingo**

Jerry said that his house (made of wood and reclaimed material) was blown over by the wind and completely destroyed by 'the flood' and he was briefly knocked unconscious by flying debris. According to PHIVOLCS (2006a), San Isidro was affected by hyperconcentrated flow and flood deposition of between 3m and 4m. He lives adjacent to an outwash plain where the rest of the barangay downstream was also badly affected by the lahar. The flow that inundated here reached the sea. He and his father returned after spending a day in an evacuation centre to rebuild their home. They were given no help to do so and Jerry felt that the downstream residents badly affected by the lahar were seen as more of a priority by the barangay officials for resettlement than he and his father.

## Appendix I: Mayon lahar database and associated rainfall

Two tables containing details of the lahars studied for the purpose of evaluating the critical rainfall intensity threshold in Chapter 7. Table 1 outlines the available data regarding the lahars and table 2 presents the data used in the analysis – the lahars, rainfall and time since the last eruption. The 2001 lahar event mentioned in Table 6.1 (Chapter 6) is not included as its true date of occurrence could not be determined.

Table 1 Lahars that have occurred between 1978 and the end of 2011.

| Event date | Syn- or post-eruptive | Description of flow | Duration | Details | Timing | Location/impact | General impact | Velocity | Volume/ Area | Type of weather event | Source of information |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *30/06/1981* | Non-eruptive | Mudflows | | Heavy rain triggered lahars. | Approx. 20:00 | Mudflows triggered by continuous rains wept villages in the S and E sectors of Mayon. 40 killed, 9 injured and 7 missing. Other casualties reported from the typhoon itself. | | | | Typhoon (or tropical storm?) | Ramos-Villarta et al. (1985); Smithsonian (O. Peña, COMVOL, Quezon City) |
| *13/09/1984* | Eruptive | First debris flow pulse | | | | Maninila channel. [Not sure when but the lone casualty caused by the eruption was from a lahar; Umbal | | | *Total volume and area of inundation of the 1984 lahars as* | | Okkerman et al. (1985) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (1986)] | | | *estimated by Umbal (1986) as 10^6m^3 over an area 3.9km^2 (Rodolfo, 1986)* | | |
| *14/09/1984* | Eruptive | Hot lahar (destructive mudflows) | Estimates from half an hour to one to two hours or even 12 hours. | Followed by 12 hot lahars. | | S and SW sectors, inundated several barrios, destroyed the Padang and Lidong bridges, and spread a thin sheet of mudflow deposits over 10,000 hectares of farmland around the base of the volcano. | | 2-5m/s | | - | Ramos-Villarta et al. (1985); Corpuz, 1985; Umbal (1985) |
| *16/09/1984* | Eruptive | | | | | | | | | | Corpuz (1985) |
| *18/09/1984 (to 19/09/1984 ?)* | Eruptive | | | | | | | | | | Corpuz (1985) |
| *23/09/1984* | Eruptive | Debris flow/mudflows/ stream flow | | 23-24 three fluxes at 3 hour intervals in Sto. Domingo Golg Couse channel (Okkerman et al., 1985) | | Subsequent mudflows followed radiating gullies in the SE and E sectors where most pyroclastics were distributed as a result mainly of the 23 and 25 September eruptions. | | | | | Corpuz (1985) |
| *25/09/1984 - 26/09/1984* | Eruptive | | | | | Subsequent mudflows followed radiating gullies in the SE and E sectors | | | | | Corpuz (1985) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | where most pyroclastics were distributed as a result mainly of the 23 and 25 September eruptions. | | | | | |
| *27/09/1984* | Eruptive | | | At least 5 flows | | Destroyed three sections of Legazpi-Santo Domingo highway (8km SE volcano); two bridges along Mailipot-Santo Domingo highway (8km E volcano). | | | | | Bulletin of Volcanic Eruptions (1987) |
| *11/10/84* | Post-eruptive | Debris flow | 1hr 5 min | Debris flow signal | | Basud pyroclastic fan/channel. | *Oct/Nov/Dec recorded as Misericorida SE Mayon). Cumulative area of 3.9km squared was affected between 1984-1986. 8000 hectares of arable land was destroyed resulting in 42 million pesos worth of crop damage. 158 houses were destroyed. Poisoning of* | | | | Okkerman et al. (1985) |
| *12/10/84* | Post-eruptive | Debris flow | 1hr 10min | Weak debris flow signal | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *14/10/84* | Post-eruptive | Debris flow | 1hr 10min | Medium intensity debris flow signal | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *16/10/84* | Post-eruptive | Debris flow | 1hr 35min | Weak debris flow signal | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *17/10/84* | Post-eruptive | Debris flow | 1hr 20min | | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *19/10/84* | Post-eruptive | Debris flow | 1hr 20min | Medium intensity debris flow signal? | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *20/10/84* | Post-eruptive | Debris flow | 1hr 40min | Strong debris flow signal | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *22/10/1984* | Post-eruptive | Debris flow | 1hr | Very strong debris flow | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *28/10/84* | Post-eruptive | Debris flow | Low intensity: 40 min, 50min; not stated: 50min, 40min | 4 flows: 2 weak; 2 not mentioned | | Basud pyroclastic fan/channel. | *fruit bearing trees that survived flows (Umbal, 1986). According to, Abundant loose ash and coarser ejecta in upper and middle slopes mobilised by intense rainfall into 67 lahars. South-eastern sector lahars - as supply of loose volcaniclastic debris depleted, steady decrease of frequency of lahars. Along 32 gullies and channels in all sectors of the volcano; no casualties (Bulleting of Volcanic Eruptions, 1987).* | | | | Okkerman et al. (1985) |
| *05/11/84* | Post-eruptive | Mudflow | 2hr | Low intensity mudflow signal | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *09/11/84* | Post-eruptive | Debris flow | 1hr 10min; >2hr (strong signal) | 2 flows (one strong signal) | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *10/11/84* | Post-eruptive | Debris flow | 1hr 15min | Signal detected | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *1/12/84* | Post-eruptive | Debris flow | 30min | Signal detected | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *30/12/84* | Post-eruptive | Debris flow | >2hr | Very strong debris flow | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *16/01/85* | Post-eruptive | Debris flow | 1hr 15min | Low intensity | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *26/01/85* | Post-eruptive | Debris flow | 1hr 30 min | Very strong debris flow signal | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |
| *27/01/85* | Post-eruptive | Debris flow | 1hr for strong | 2 flows (very strong signal and low intensity) | | Basud pyroclastic fan/channel. | | | | | Okkerman et al. (1985) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *18/10/1985* | Post-eruptive | Lahar (debris flow) | Lasted 9 hours (according to residents) - unknown which proportions were normal streamflow, hyperconcentrated streamflow and debris flow. | Typhoon Dot (Saling I). | | Generated debris flows that avulsed from the middle stretch of Mabinit Channel and buried large areas that had been unaffected by lahars since well before the 1984 eruption. Debris flows that avulsed from the middle stretch of the Mabinit Channel (over topped the lower reaches). Enhanced definition of the channels so that some of the cold flows were notably deeper than the hot debris of 1984 and thus overtopped in the lower reaches of the Mabinit channel where it was about 5m deep. | | Minimum estimate of 3.8m/s (calculated utilising tendency of fluid flows to reach higher elevations on outside of the channel [Mabinit] bend) (Rodolfo et al., 1989) [2.5-4.75m/s - Rodolfo and Arguden (1990) | (200000m^2 x average 1m thick) | Typhoon | Rodolfo (1989); Rodolfo et al. (1989); Arguden and Rodolfo (1990); Rodolfo and Arguden (1991). |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *14/11/87-15/11/87* | Non-eruptive | Lahar (major debris flow phase) | ? | Tropical storm Rosing. Enhanced definition of the channels so that some of the cold flows were notably deeper than the hot debris of 1984 and thus overtopped in the lower reaches of the Mabinit channel where it was about 5m deep. | | Mabinit Channel. [Not sure this is the correct record: Maximum of 45 metres of lateral erosion and 2.5 metres of vertical erosion during the passage of 'Typhoon Rosing lahars'] | | 2-4 m/s (Arguden and Rodolfo, 1990) | | Tropical storm | Rodolfo and Arguden (1991) |
| *20/11/1987* | Non-eruptive | Lahar (major debris flow phase) | | Exceptional heavy monsoon. Major debris flow phase that caused large-scale channel modification. | | Same site as Saling (275-268m) - minor avulsion. | | | | Monsoon | Rodolfo and Arguden (1991) |
| *14/08/1988* | Eruptive (increased activity) | Lahar | | Lahar moved SE. | Approx. 21:00 | Basud, Matanag, and Mabinit gullies and was recorded on the Santa Misericordia Station (SMS) about 8 km E of the crater (figure 4). Field observations indicated that the lahar eroded 1.3 m of the Matanag gully near the Buyuan-Matanag road. Major overtopping extending to the Mabinit-Bonga road ($2.8x10^5 m^2$) | | | | | Smithsonian (PHIVOLCS) |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | area. | | | | | | |
| *29/09/1988* | Increased activity | Lahar | | Steaming; mudflow with a velocity of 2.3 m/s | | Basud gully | | | | | | Smithsonian (PHIVOLCS) |
| *12/10/1988* | Increased activity (VE) | Lahar | | Mudflows detected by seismographs and mapping team. Basud lahar moved at 2.5m/s. | Between 2347 and 0141 the next morning (13th October) | Basud gully | | | | | | Smithsonian (PHIVOLCS) |
| *23/10/1988* | Increased activity (VE) | Lahar (major debris flow phase) | | Typhoon Ruby (Unsang) mudflows detected (by seismographs and by a lahar mapping team) | | | | 2.75m/s (Arguden and Rodolfo, 1990) | | Typhoon | | Smithsonian (PHIVOLCS) |
| *04/11/1988* | Increased activity (VE) | Lahar (major debris flow phase) | | Typhoon Skip (Yoning) may have brought the rainfall. Lahars detected (by seismographs and by a lahar mapping team) | | SE and SW slopes | | | | Typhoon? | | Smithsonian (PHIVOLCS); Rodolfo and Arguden (1991) - ref to Skip |
| *06/11/1988* | Increased activity (VE) | Lahar | | Lahar detected by seismographs and mapping team | | SE and SW slopes | | | | From above typhoon? | | Smithsonian (PHIVOLCS) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *20/11/1988* | Increase d activity (VE) | Lahar (major debris flow phase) | | Monsoon triggered mudflows detected by seismographs and mapping team | | SE and SW slopes | | | | Monsoon (five days of antecedent rainfall that may be significant?) | Smithsonian (PHIVOLCS); Rodolfo and Arguden (1991) |
| *21/11/1988* | Increase d activity (VE) | Lahar | | Mudflows detected by seismographs and mapping team | | SE and SW slopes | | | | | Smithsonian (PHIVOLCS) |
| *14/02/1989* | Non-eruptive | Lahar (major debris flow phase) | | Monsoon triggered lahar with major debris flow phase. Major debris flow phase that caused large-scale channel modification. | | | | | | Monsoon | Rodolfo and Arguden (1991) |
| *10/10/1989 (date of typhoon)* | Non-eruptive | Lahar (major debris flow phase) | | Typhoon Dan (Saling II) | | | | | | Typhoon | Smithsonian (PHIVOLCS); Rodolfo and Arguden (1991) |
| *18/02/1993 - 23/02/1993 (reports of eruption ending in March 1993 and 04/04/1993 )* | Eruptive | Hot lahars | | Hot lahars; last half of Feb, moderate to heavy rains on the SE flank remobilised the new pyroclastic deposits and generated small lahars. | | Confined to gullies. | | | | | Smithsonian (PHIVOLCS) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *03/03/1993* | Eruptive | Lahar | | Smell of sulphur noted five minutes prior to arrival of lahar at 15:30. Knee-deep and warm (but not boiling). Little rainfall. | 15:30 | | | | | | Smithsonian (PHIVOLCS) |
| *02/11/1995* | Post-eruptive | Lahar | | Lahars generated by Typhoon Angela (Rosing). | | | | | | Typhoon | APSEMO |
| *21/10/1998 - 22/10/1998* | Post-eruptive | | | Typhoon Babs (Loleng) | | Unknown | | | | Typhoon | APSEMO |
| *03/03/2000* | Eruptive | Lahar activity | | | | Anoling-Salvacion, Tumpa, Quirangay and Maninila Channels | | | | | Catane et al. (2005) referencing Bornas et al. (2000) |
| *01/12/2004 - 02/12/2004* | Post-eruptive | Lahar | | Typhoon Yoyong induced lahars. According to a news report, strong rains brought by typhoon Yoyong in the Philippines caused lahars to flow down the stream channels of Mayon, particularly in the Padang settlement, and Legazpi City (~14 km SE of the volcano's summit). The Provincial Disaster Management Officer stated that the lahars | | Padang and Legazpi | | | | Typhoon | Smithsonian (ABS-CBN News) |

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| | | | | would not cause damage to homes or rice fields, and that villagers residing near the volcano were not asked to evacuate (GVP, 2004). | | | | | | | |
| *27/09/2006* | Post-eruptive | Debris or hyperconcentrated? | | Typhoon Xangsane (Milenyo). | | Lidong and Padang (the occurrence in Padang highlighting the increased risk due to the stream piracy). | | | | Typhoon | PHIVOLCS (2007a and 2007b) |
| *30/11/2006* | Post-eruptive | Debris flow and hyperconcentrated flows | Until around 5pm? | Typhoon Durian (Reming). Two to three pulses of debris flows and hyperconcentrated flows. | (10:00 and) 14:00 | Guinobatan, Camalig, Daraga, Legazpi, Padang, Sto. Domingo. Over 100 deaths. | | | | Typhoon | Smithsonian (PHIVOLCS) |
| *25/07/2011 - 26/07/2011* | Post-eruptive | Lahar | | Tropical depression. One resident (Maipon) indicates that lahars occurred from 6am to 2pm on 25 July, initial flows dumped sediments on the northern portion of the lahar field but shifted south to the barangay road between 8am and 10am. But, rainfall at Legazpi station not particularly heavy until the evening of the 25th and into the 26th - did lahars occur on the | | Masarawag, Padang, Nabonton, and Basud Channels as well as in a new reactivated channel along the Legaspi-Sto. Domingo Border. | | | | Tropical depression | PHIVOLCS (2011a) |

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| | | | | 26th? | | | | | | |

Table 2 Lahars that have occurred between 1978 and the end of 2011, with the associated rainfall and time since the last eruption.

| Discrete event | Syn, post or non-eruptive | Type of weather event | Time since last eruption (months) | VEI of last eruption | Volume of last eruption (million $m^3$) | Hourly rainfall intensity | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 24 hours | 12 hours | 6 hours |
| *30/06/1981* | Non-eruptive | Typhoon | 23.93 | 2 | 20 | 8.80 | 16.42 | 23.33 |
| *13/09/1984* | Eruptive | | 0.00 | 3 | | 0.00 | 0.00 | 0.00 |
| *14/09/1984* | Eruptive | | 0.00 | 3 | | T | T | 0.00 |
| *16/09/1984* | Eruptive | | 0.00 | 3 | | 0.23 | 0.45 | 0.90 |
| *18/09/1984* | Eruptive | | 0.00 | 3 | | 0.16 | 0.27 | 0.37 |
| *23/09/1984* | Eruptive | | 0.00 | 3 | | 0.05 | 0.08 | 0.13 |
| *25/09/1984-26/09/1984* | Eruptive | | 0.00 | 3 | | 0.21 | 0.43 | 0.83 |
| *27/09/1984* | Eruptive | | 0.00 | 3 | | 0.39 | 0.75 | 1.33 |
| *11/10/1984* | Post-eruptive | | 0.20 | 3 | 70 | 2.27 | 4.53 | 9.07 |
| *12/10/1984* | Post-eruptive | | 0.23 | 3 | 70 | 0.38 | 0.75 | 1.50 |
| *14/10/1984* | Post-eruptive | | 0.30 | 3 | 70 | 0.31 | 0.62 | 0.97 |
| *16/10/1984* | Post-eruptive | | 0.36 | 3 | 70 | 1.33 | 2.67 | 5.33 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *17/10/1984* | Post-eruptive | | 0.39 | 3 | 70 | 0.00 | 0.00 | 0.00 |
| *19/10/1984* | Post-eruptive | | 0.46 | 3 | 70 | 2.18 | 2.50 | 3.70 |
| *20/10/1984* | Post-eruptive | | 0.49 | 3 | 70 | 1.78 | 3.50 | 6.83 |
| *22/10/1984* | Post-eruptive | | 0.56 | 3 | 70 | 0.59 | 1.03 | 1.97 |
| *28/10/1984* | Post-eruptive | | 0.76 | 3 | 70 | 2.93 | 5.48 | 6.13 |
| *05/11/1984* | Post-eruptive | | 1.02 | 3 | 70 | 0.55 | 1.10 | 2.03 |
| *09/11/1984* | Post-eruptive | | 1.15 | 3 | 70 | 2.79 | 4.30 | 5.33 |
| *10/11/1984* | Post-eruptive | | 1.18 | 3 | 70 | 0.37 | 0.55 | 1.10 |
| *1/12/1984* | Post-eruptive | | 1.87 | 3 | 70 | 0.91 | 1.28 | 2.03 |
| *30/12/1984* | Post-eruptive | | 2.83 | 3 | 70 | 1.47 | 2.83 | 4.87 |
| *16/01/1985* | Post-eruptive | | 3.39 | 3 | 70 | 2.06 | 4.02 | 5.67 |
| *26/01/1985* | Post-eruptive | | 3.71 | 3 | 70 | 1.73 | 2.62 | 3.07 |
| *27/01/1985* | Post-eruptive | | 3.75 | 3 | 70 | 2.41 | 3.15 | 3.63 |
| *18/10/1985* | Post-eruptive | Typhoon | 12.43 | 3 | 70 | 3.43 | 6.37 | 9.00 |
| *14/11/1987-15/11/1987* | Non-eruptive | Tropical storm | 35.34 | 3 | 70 | 3.12 | 4.37 | 5.00 |
| *20/11/1987* | Non-eruptive | Monsoon | 35.54 | 3 | 70 | 0.95 | 3.60 | 3.80 |
| *14/08/1988* | Eruptive (increased activity) | | 44.35 | 3 | 70 | 0.02 | 0.03 | 0.07 |
| *29/09/1988* | Increased activity | | 45.86 | 3 | 70 | 0.03 | 0.05 | 0.07 |
| *12/10/1988* | Increased activity (VE) | | 46.29 | 3 | 70 | 3.53 | 5.60 | 8.50 |
| *23/10/1988* | Increased activity (VE) | Typhoon | 46.65 | 3 | 70 | 3.31 | 5.57 | 8.03 |
| *04/11/1988* | Increased activity (VE) | Typhoon? | 47.04 | 3 | 70 | 4.57 | 5.73 | 8.07 |
| *06/11/1988* | Increased activity (VE) | From above typhoon? | 47.11 | 3 | 70 | 6.66 | 18.27 | 11.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *20/11/1988* | Increased activity (VE) | Monsoon | 47.57 | 3 | 70 | 7.66 | 11.55 | 17.13 |
| *21/11/1988* | Increased activity (VE) | | 47.60 | 3 | 70 | 2.35 | 3.22 | 4.10 |
| *14/02/1989* | Non-eruptive | Monsoon | 50.43 | 3 | 70 | 12.84 | 18.47 | 20.30 |
| *10/10/1989 (date of typhoon)* | Non-eruptive | Typhoon | 58.25 | 3 | 70 | 4.47 | 6.68 | 7.97 |
| *03/03/1993* | Eruptive | | 0.00 | 2 | | 1.25 | 2.31 | 2.55 |
| *02/11/1995* | Non-eruptive | Typhoon | 33.07 | 2 | 50 | 14.42 | 18.67 | 28.33 |
| *21/10/1998-22/10/1998* | Non-eruptive | Typhoon | 68.74 | 2 | 50 | 13.08 | 15.18 | 20.00 |
| *03/03/2000* | Eruptive | | 0.00 | 3 | | 1.39 | 1.84 | 3.68 |
| *01/12/2004-02/12/2004* | Non-eruptive | Typhoon | 39.88 | 3 | 54.3 | 5.76 | 9.75 | 10.20 |
| *27/09/2006* | Non-eruptive | Typhoon | 61.74 | 3 | 54.3 | 9.83 | 16.53 | 25.00 |
| *30/11/2006* | Non-eruptive | Typhoon | 62.82 | 3 | 54.3 | 20.38 | 38.83 | 47.50 |
| *25/07/2011* | Non-eruptive | Tropical depression | 18.74 | 3 | 54.3 | 7.13 | 3.27 | 2.03 |

# Appendix J: Data from multi-hazard feedback questionnaire

The following information is from the 11 responses (A-1), including the 'no response', to the question: In your experience please list three core barriers to assessing multi-hazards. This question comprised part of a feedback form from the 21st June 2012 Interagency Resilience Working Group Workshop - Integrating Science into humanitarian and development work to enhance resilience, linking science and traditional community knowledge. See Appendix A for more details of this event.

In your experience please list three core barriers to assessing multi-hazards

**A**

(1) Short-term thinking.
(2) Not seen as a priority.
(3) Lack of understanding.

**B**

(4) The lack of scientific knowledge within organisation.
(5) Resource constraints for multi-hazard approach

**C**

[NO ANSWER]

**D**

(1) Local knowledge of where to access relevant scientific knowledge
(2) Challenge of interpreting that information
(3) Lack of capacity in country (and UK) project teams to do the above

**E**

(1) Silos of expertise (different tables echo this)
(2) PCVAs – good for comprehensive approaches but not necessarily easy to bring in science.
(3) Related – community driven – focusing on most salient risks.

**F**

(1) Understanding the full system(s) – political, social, economic, environmental – they occur in.
(2) NGO culture and dependency culture destroying local knowledge
(3) Political will to address real underlying issues/causes.

**G**

(1) The way knowledge is often 'siloed' – lack of integration.

**H**

(1) Lack of organisational interest
(2) Difficulty of getting funds to doing multi-hazard assessments
(3) We are reactive organisations; contingency planning has a chequered history in NGOs

**I**

(1) Tendency to focus on the most recent event
(2) Not able to cope with the complexity of multiple hazards
(3) Looking at different hazards in isolation rather than understanding the interplay between them

**J**

(1) Scientific info too general (covers large area).
(2) Translating local knowledge (sometime too localised).
(3) Linking various disciplines in country.

**K**

(1) Lack of knowledge and awareness of multi-hazard analysis.
(2) For NGO, many times assessments are donor-driven, therefore focus on specific issues.

## Appendix K: Guidelines for integrating science

The following pages (441 to 490) contain a copy of the guidelines for 'integrating science into humanitarian and development planning and practice for enhancing community resilience' by Duncan et al. (2014). The copy of the guidelines includes its original page numbering.

# Integrating science into humanitarian and development planning and practice to enhance community resilience

## Full guidelines

**Lead Author: Melanie Duncan (UCL)**

**Co-authors:** Kate Crowley (CAFOD), Ros Cornforth (AfClix), Stephen Edwards (UCL), Richard Ewbank (Christian Aid), Parisa Karbassi (CAFOD), Charlie McLaren (UKCDS), Jose Luis Penya (Christian Aid), Alice Obrecht (HFP), Susanne Sargeant (BGS), Emma Visman (HFP)

**January 2014**

***Cover photo:*** *Dr Megan French of University College London (UCL) collects samples for water quality analysis in the Bolivian Altiplano with Efrain Blanco Coariti of the Instituto de Investigaciones Químicas, Universidad Mayor de San Andres, Bolivia, a local partner of the Catholic Agency for Overseas Development (CAFOD). The research is coordinated by the UCL-CAFOD partnership. Source: M. French, February 2013.*

## Purpose of the guidelines

These guidelines are for humanitarian and development practitioners looking to effectively integrate relevant scientific understandings of risk within their humanitarian/development planning and practice, for the purpose of enhancing community resilience. Beginning with an introduction to what science is and how it might be used, followed by a breakdown of the key components for integrating science these guidelines encourage practitioners to think about the types of scientific information and expertise that they may need, how to access and use them, and how to ensure that they are applied in an ethical and accountable manner. Each section concludes with a checklist of key questions practitioners should consider throughout the process.

These guidelines are not exhaustive or prescriptive instead the aim is to enable practitioners to ask useful questions that will ultimately help them to apply science in their planning and operational decision-making. While the authors acknowledge that invaluable knowledge resides in communities at risk, the draft guidelines are about how to utilise scientific and technical expertise from external institutions.

The intended audience is those practitioners looking to integrate science information at any stage of the project cycle. Discussed are the wider scale application of science and some of the organisational challenges in fostering partnerships with scientists, thus this document is also of interest for management and across different departments within an organisation.

The objectives of the guidelines are as follows:

- to describe what science is and how it can be applied to humanitarian and development planning and practice in order to build resilience;
- to provide some initial guidance to NGO practitioners upon how they can access and use science;
- to demonstrate that engagement with scientists is through multi-stakeholder co-production of knowledge;
- to emphasise the need for ethical, credible and mutually beneficial engagement with science and scientists;
- to emphasise the need to monitor and evaluate the impact of integrating science;
- to highlight how to overcome the common pitfalls NGOs face when integrating science into their activities and how to overcome them.

The internalisation of science within NGOs is important; thus it is the recommendation of the authors that to complement the guidelines, NGOs need to incorporate scientific training within the professional development of relevant staff.

The authors acknowledge that a paired document for scientists to better understand how practitioners can receive, understand and influence scientific research is also required.

## Table of Contents

## Executive summary

There has been an increased emphasis upon the application of science for humanitarian and development planning, decision-making and practice; particularly in the context of understanding, assessing and anticipating risk (e.g. HERR, 2011). However, there remains very little guidance for practitioners on how to integrate sciences they may have had little contact with in the past (e.g. climate). This has led to confusion as to which 'science' might be of use and how it would be best utilised. Furthermore, since this integration has stemmed from a need to be more predictive, agencies are struggling with the problems associated with uncertainty and probability.

Whilst a range of expertise is required to build resilience, these guidelines focus solely upon the relevant information, knowledge and perspective which *scientists* can provide, that typically lie outside of current humanitarian and development NGO approaches. However, the process of building resilience involves the communication and co-production of knowledge across a number of stakeholders, including the community knowledge of the risks they face. The process of integration of science should, therefore, be mutually beneficial to all stakeholders.

Integrating science requires an **iterative process of engagement** through the continual revisiting of the components of five activities:

| | |
|---|---|
| **1. Defining the problem to be addressed:** | |
| ***Do you (the practitioner) know what sort of information you require?*** | Begin by identifying and defining the problem to be addressed. This will help establish an aim and set of objectives to determine what sort of information is necessary and, thus, know what questions to ask of scientists. Knowing what questions to ask is a key enabler in obtaining access to scientists: **it is easier to build a dialogue around an initial set of questions, rather than a vague concept**. Having a clear aim and a set of objectives will also help in monitoring and evaluating the success or failure of the integration of science. |
| **2. Accessing the scientific information, knowledge and expertise:** | |
| ***Do you know where and how to access scientific information?*** | Science can be accessed both through **open-sources** and directly with **scientists. A particularly effective mechanism of engagement is through partnerships with scientific organisations**. Engagement with local scientists helps to ensure sustainability of this knowledge exchange and the process of integration should aim to be inclusive of all relevant stakeholders and experts. Partnerships take time, commitment and resources to build and they may take time to deliver benefit. However, by **proactively** setting up a partnership that involves **good communication** with scientists, a relationship will exist in advance of immediate needs and, as such, scientists are more likely to be available in the event of a demand for information under short time constraints. |
| **3. Understanding the science and assessing its credibility:** | |
| ***Do you, your partners and the communities you work*** | Practitioners and other users of science need skills to determine the **credibility and uncertainty** of the science they are using and whether |

| | |
|---|---|
| ***with understand the science?*** | or not it is fit for purpose. There are basic measures that can be adopted to ensure the scientific information is **trustworthy and representative of the real world**. Seeking out more than one source of information and appreciating scientific debate are just some of the ways in which the quality and relevance of scientific information can be verified. |
| **4. Applying scientific information and methods:** | |
| ***Do you know how to apply scientific information and methods in an ethical and accountable manner?*** | Whilst scientists and NGOs are both bound by ethical/accountability frameworks alike, it is important to have an agreed set of values prior to meeting with a community. **Accountability mechanisms should be put in place to protect scientists, NGOs and communities**. |
| **5. Measuring the impact of the science integration:** | |
| ***Do you know how to measure the impact of science integration within your project?*** | The impact of integrating science can be measured in order to determine whether there has been a positive (or negative) change to a vulnerable communities' situation. This can be achieved throughout the programme cycle but requires the **monitoring of science integration within the project or programme framework from the start**. |

**Key considerations when integrating and using science:**

| | |
|---|---|
| **Managing expectations:** | Being aware of the limits of science and scientists will help to facilitate partnerships with scientists, who should also be aware of the expectations of communities, and the constraints upon them that may affect their ability to participate. |
| **Knowing the suitable entry point:** | Ideally science (just as with any other relevant knowledge) should be used to inform the analysis for and design of any implementation activity. However there may be instances where it is more appropriate to introduce different types of science later in the project cycle. |
| **Science integration should be a positive and beneficial process for all parties involved:** | Using science should not be burdensome if the process of engagement is well managed and a proactive approach to accessing the science is adopted. Practitioners should not be put off by uncertainty as all decisions are based on a degree of uncertainty, which should stimulate debate that leads to improved decision making. |
| **Communities are interested in and can understand science:** | If well communicated, communities can deal with a number of scientific concepts and uncertainty and make well informed decisions based on this and their own knowledge and understanding. They can also inform the science and participate in scientific research. |

In conclusion being able to evaluate the ***credibility*** of the information and ***co-produce the knowledge to inform decision-making and action*** through ***partnerships with scientists*** and ***good communication and understanding*** of the science will improve projects and build an evidence base to ***inform future research strategies and influence donor funding*** for this type of work.

## Definitions

***Community**: a group of people living in the same area or close to the same risks and/or with common interests, values, activities and structures. Communities are, however, complex and not always united. They have socio-economic differentiations, linkages and dynamics that contribute to vulnerability. Communities do not exist in isolation – a level of a community's resilience is also influenced by capacities outside the community[1]. For the purposes of this document, we use the term 'community' to refer to 'community at risk'.*

***Integrated science**: the incorporation of all the relevant, available and credible sources of natural and social scientific information and knowledge deemed essential for solving a humanitarian/development problem and thereby contributing to increased resilience.*

***Resilience:** the capacity of an individual, household, population group or system to anticipate, absorb and recover from shocks and stresses without compromising long term prospects. Resilience is not a fixed end state, but is a dynamic set of conditions and processes[2].*

***Science:** pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence[3].*

***Scientist:** a person who works in the advancement of science, either natural or social, typically working within a specific scientific discipline. In the context of this document, a scientist is seen as someone with knowledge and expertise that have potential application to resilience building.*

***Practitioner:** a person who applies their expert knowledge to a certain profession, in these guidelines this refers primarily to the development and humanitarian sector.*

"

**Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in a language comprehensible to everyone** *– Professor Albert Einstein*

"

[1] Modified from Twigg, J. 2007. *Characteristics of a disaster resilient community: A guidance note.* DFID Disaster Risk

[2] Modified from Turnball et al., 2013. *Towards Resilience*. Emergency Capacity Building Project.

[3] Science Council, 2013. *What is science?* Available online: http://www.sciencecouncil.org/definition

## Introduction: What is science and why is it useful?

Science is the '**pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence**'[4]. Natural science is comprised of those branches of science that attempt to understand the rules that govern the natural world, typically through quantitative scientific methods, whilst social science is the study of people and society and typically adopts qualitative as well as quantitative approaches to data collection and analysis (see section 3 for an explanation of qualitative and quantitative data). Through scientific research, theories and models are constantly refined so that they become closer to reality. However, it is important to remember that these will never fully represent the real world and that there will always be uncertainty.

In terms of building resilience 'science' and 'technology' are very much complementary, but they are not the same; technology (along with engineering) refers more to the application of scientific knowledge[5].

Science is often used indiscriminately to refer to data, information, knowledge, expertise and research. **Data** are the observations made (raw facts) that are of little usable value, until the actor inserts meaning[6] and refines the data into **information**, which is ultimately transformed (through individual experience and values) into **knowledge,** by trading and evaluating information through dialogue[7].

The aspiration of science integration should be the co-production and co-application of knowledge for the purposes of building resilience:

> *'Seeing information and knowledge as components of adaptive capacity would encourage actors to put more emphasis on giving people a wider range of information, appropriate to a much wider range of circumstances and future scenarios; giving people the tools to find information for themselves; and turning information into knowledge by supporting people's ability to use the information for decision-making.'* (Levine et al., 2011: viii).

In order to be useful scientific information must be based upon rigorous **methodologies and research principles**, so as to ensure the credible collection and robust analysis and reporting of data. These principles include making sound observations and conducting experiments, so that one researcher could replicate the experiment and findings of another. Furthermore, scientists continually challenge and ask questions of existing theories in order to improve and progress scientific understanding.

In terms of humanitarian and development planning and practice and decision-making, scientific information and methods can help inform decision-making in many ways:

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[4] Science Council, 2013. What is science? Available online: http://www.sciencecouncil.org/definition
[5] Conway, G. and Waage, J., 2010. Science and Innovation for Development. UK Collaborative on Development Sciences.
[6] Davenport, T. H. and Prusak, L., 1998. Working Knowledge. Harvard Business School Press, Boston, Massachusetts.
[7] International Federation of Red Cross and Red Crescent Societies (IFRC), 2005. World Disaster Report, 2005. Focus on information in disasters.

- scientists use theories and techniques for modelling (creating visual representation of situations or scenarios) and extrapolation (making conclusions when there no data);
- models can be used to build scenarios and make predictions in order to anticipate risk, as well as explain environmental change and human behaviour, within varying degrees of certainty;
- science can be used to support or validate other sources of knowledge (e.g. local knowledge) and the two can inform each other;
- scientific information and understanding can help to interpret processes at many scales, from local level flooding to global climate change that may affect communities;
- the scientific approach encompasses a set of methods that can help to ensure the credible and accountable collection, analysis and reporting of data, as well as rigorous methods with which to tackle a problem (e.g. hypothesis testing).

In terms of project cycle management (PCM)[8], scientific information and knowledge can be of great assistance during the analysis phase, helping to shape the project design and intervention strategy. In the long-run, this will save time, resources and reduce the possibility of oversights. Where possible, science should therefore be included from the outset of the PCM process with engagement continuing throughout the duration of the project. The impact of science integration should, therefore, be continuously monitored and reviewed throughout the project or programme, with methods for monitoring established from the outset.

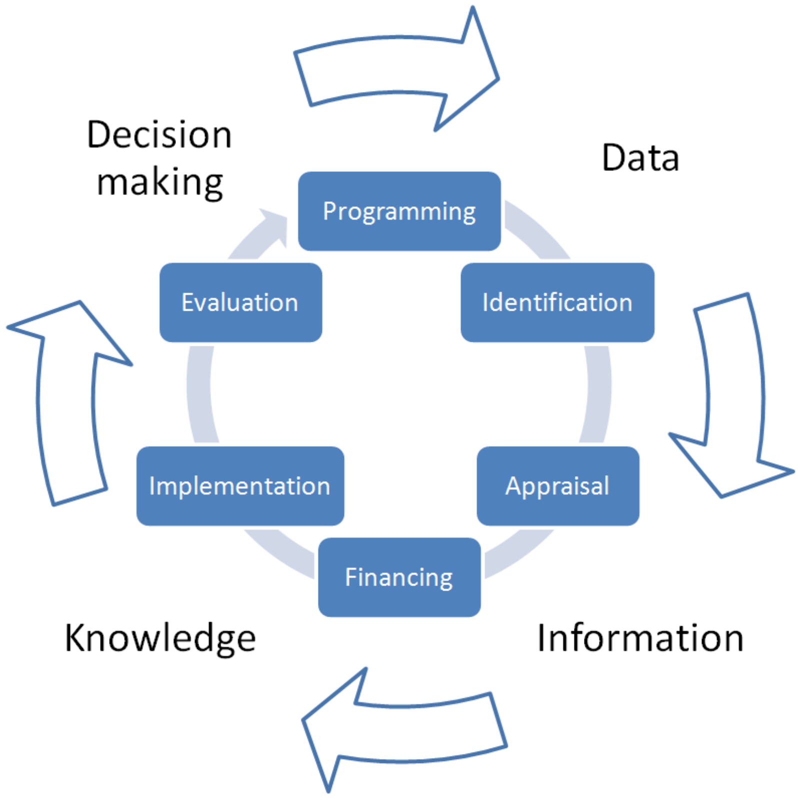


**Figure 1: The inner circle represents the PCM stages, whilst the outer circle represents the stages of science production.** Source: adapted from the EC manual: project cycle management 2001

[8] Turnball et al., 2013. Towards Resilience. Emergency Capacity Building Project.

## Science integration

For the purpose of these guidelines, we define science integration as the **incorporation of all the relevant, available and credible sources of natural and social scientific information and knowledge deemed essential for solving a humanitarian/development problem and thereby contributing to increased resilience.** Science can be applied at a number of scales, even within a single project or activity. Reflections from a knowledge-exchange partnership project in Bangladesh demonstrate some of these multi-scale opportunities for engaging with science (see case study 1).

### Case study 1: Integrating science at different scales – reflections from Bangladesh

*In terms of building resilience, Bangladesh faces many challenges, not least because of the range of hazards, both natural and man-made, to which it is exposed; a single community could be exposed to arsenic contamination, cyclones, flooding and earthquakes. Although Bangladesh is particularly known for its exposure to weather- and water-related hazards, it also has a history of very large earthquakes – some as large as magnitude 8; however, there have been no earthquakes greater than magnitude 7 since the 1930s, and there is no community memory of such events.*

*For practitioners, this is where integrating science into projects can be extremely valuable and supplement the community understanding of risk (here, for raising community awareness of the threat in general and for informing operational decisions for a particular scenario). Other examples include using scientific understanding of arsenic contamination to identify safe water sources. One of the challenges here is to build resilience to hazards with different annual probabilities (i.e. cyclones happen relatively frequently but large earthquakes are comparatively more rare).*

*Scientific information is available at the international, national, sub-national and community scale and research and monitoring are being undertaken by local and international scientists, often working together. However, available information is often fragmented, and may not be easily accessed or found in peer-reviewed journals (because the research has been commissioned specifically for a particular purpose).*

| | *National* | *Sub-national* | *Local* |
|---|---|---|---|
| **Risk assessment**: understanding the source and nature of the problem and anticipating disasters with confidence. | National and international scientists are involved in developing information to inform the national Comprehensive Disaster Management Programme | National and international scientists have developed earthquake scenarios for Dhaka, Sylhet and Chittagong and there are plans to extend this to other cities | Provision of daily/seasonal weather forecasts to farmers; locally relevant data; basic earthquake information is available from the Meteorological Department |
| **Awareness raising and education** | | | Education about disasters from unsafe drinking water to what to do during an earthquake |
| **Technology** | | Developing low-cost sanitation techniques applicable to context | ICTs to provide market information to local farmers to inform decision-making |
| **Communication** | Knowledge dissemination to policy-makers. | | |

**Table 1: Examples of the integration of science for different purposes and scales in Bangladesh**

**Figure 2: caritas Bangladesh worked with the Bangladesh University of Engineering and Technology to survey salinity levels in the soil and test a solar powered water purification system. This has created a new long term relationship between scientists and practitioner, in addition to enabling new innovations and ideas to improve the health of families such as Kakoli and her son Ruhan pictured here.** Source: Kate Crowley, CAFOD.

### *Where is the entry point for integrating science?*

Any project, programme or strategy should be informed by a rigorous analysis of the problem using all available relevant information and data, and yet there is a tendency to bring in science at the end of this analysis (or not at all). Ideally, integrating science should occur throughout a NGO's way of working; however this requires strategic decision-making and even a degree of organisational change. A natural existing entry/starting point for integrating science is via projects. Evidence of impact through integrating science within projects can be used to inform management about the benefits and limits of integrating science, which could shape strategic planning[9]. Similarly, through engagement with NGOs, communities and other users of science, scientists can gain a better understanding of what research is required and, therefore, help to better inform future research strategies.

Consulting with scientists from the very outset can help to ensure that the range of risk is fully considered. In reality, however, some expertise or information may only be recognised as necessary further down the line. Close consideration of the entry point for science is necessary in order to manage expectations of all stakeholders as well as, in the case of community participation, ensuring empowerment of and co-ownership of the process by the community.

[9] See ELRHA case study 3: *A research and knowledge sharing partnership between UCL and CAFOD*

Integrating science is not simply about the application of science but, through the process of engaging with science, the learning that is acquired and the integration of all relevant information in order to co-produce knowledge between stakeholders (e.g. scientists, NGOs and communities) of the risks communities face and what they must do to address these.

For the purpose of these guidelines, the integration of science should be considered as an iterative process within a cycle that can be subdivided into five components:

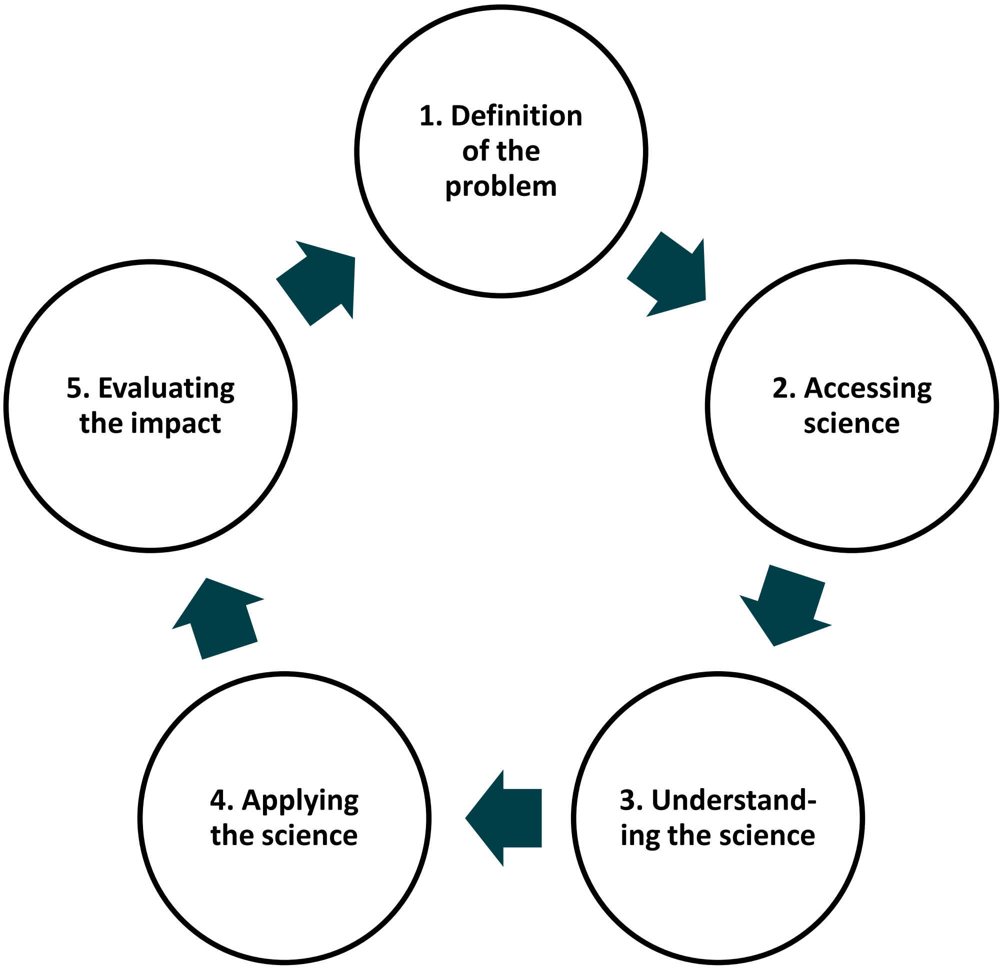


**Figure 3: The five components of integrating science.**

In the cycle, the implementation of one activity may necessitate going round this cycle several times as the scientific information changes and is updated. For example, you may feel that the problem has been identified from the outset, however it may only become apparent on engaging with scientists and trying to apply the science what the true or underlying problem really is. The purpose of describing the process of integrating science as a series of components is simply to frame the main areas for consideration and demonstrate how to address them with evidence from existing case studies in Bangladesh, the Democratic Republic of the Congo (DRC) and the Philippines, as well as fictional examples. At the beginning of each section there is a checklist of the key questions you as a practitioner need to consider when integrating science.

## Section 1: Defining the problem to be solved and the purpose of integrating science

**There are a number of scientific disciplines that can assist in building resilience; therefore it is important to clearly define the problem to be solved and the information and expertise that will be required. It is understandable that it may not always be possible to know which science is required, so it is advisable to consult with experts either within (e.g. technical advisors) or external (e.g. academics in universities or national scientific agencies) to you organisation.**

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- ✓ *Have you clearly defined the problem to be addressed?*
- ✓ *Do you have a clear purpose for applying science?*
- ✓ *How will the application of science benefit the community/the project objectives?*
- ✓ *Do you have an initial understanding of what data, information and knowledge is required?*
- ✓ *Have you thought of some initial questions to ask of scientists?*
- ✓ *Have you considered what you need to be monitoring to ensure that you measure the impact of integrating science from the outset?*

---

The type of scientific information, knowledge and methods required will vary across projects and programmes depending on the problem needing to be addressed. By first identifying and defining the problem you (and the community) will have a clearer understanding of the purpose of integrating scientific information and knowledge and, as such:

- An initial understanding of what scientific information is required, which will help you to know what relevant and focused questions should be asked of a scientist.
- A reference point against which you can monitor the process and impact of integrating science from the outset of engagement.

It is important to be flexible in defining a problem (setting out the purpose of integrating science), as this is likely to alter once you start to gather the necessary scientific information. Communities' may have a perception of what the problem is, but additional information may highlight other concerns that they were previously unaware of. Furthermore, where possible be proactive and anticipate what you may have to address before the onset of a humanitarian crisis.

The questions below and in the checklist above are designed to help you think through the purpose of integrating science and are exemplified using a fictional example of a project.

### *What is the problem to be addressed?*

Say, for example, that the community are describing an increase in the frequency and severity of flooding. You wonder whether it might be due to changing climate but you do not have any evidence to support this. You suspect that there might be other local influences on the frequency and severity of flooding but the evidence presented by the community gives little indication of this. You hope that, by using what science is available, you/the community will be able to identify the triggers for flooding and therefore take the appropriate action to reduce local vulnerability. In this example, the aim of integrating science could be:

- To determine the cause of increased frequency and severity of flooding and inform local communities to enable them to adapt their Disaster Risk Reduction (DRR) strategies accordingly.

In order to realise this aim, a set of objectives might include:

- investigate relevant and credible[10] background scientific information services (e.g. from the web, scientific journals);
- seek advice from an appropriate scientist or scientific institution;
- conduct an analysis to determine the frequency and severity of flooding with the scientist's and community's knowledge;
- hold a workshop for disseminating the results of this analysis;
- promote DRR strategies that utilise this information.

Before seeking out scientific information and expertise, it is useful to think about what the current knowledge and information gaps are, in order to help determine with whom might be the best person to consult.

### *Where are the current knowledge gaps?*

Continuing with the above example, the community may recollect several periods where flooding was more frequent but not nearly as bad as it is now. One family show you the height of the most recent flood which left a watermark against the outside wall of their house and indicate the floods 20 years ago only reached half this height.

[10] See section 3

**Figure 4: Community members pointing out the depth of flood waters during 2011 in Mongla, Bangladesh.** Source: Kate Crowley, CAFOD.

You estimate the recent flood height as two metres above the current river height. Only one or two members of the community are able to evidence the change in flood height, the rest discuss it relatively (higher or lower than before); but all agree there has been an increase in the number and severity of floods. They describe different types of flood (e.g. fast, slow; from the river or from rainfall) but using their own descriptions and language. You want to compare this to changes in rainfall but you do not have access to records for the area or do not know where to get them. You are not aware of any maps to show how land use planning may have changed and consequently affected flooding (e.g. deforestation); although the community are unaware of any local changes.

### *What information is needed?*

You deem it necessary to determine whether there is any supporting information that could help check the information provided by the community as well as explain the reasons for the changes in flood frequency and severity. In the long-term, it would be useful to establish a systematic method of measuring flood levels and rainfall; for example measuring the flood level at the same location using a river level gauge or predefined marker against a building each time it floods would ensure a reliable baseline of data are being gathered. In the short-term, more information on changes in local land use planning, along with information on previous floods, rainfall records and any available flood hazard maps would prove useful. An expert in water basin management could help to determine whether factors beyond the reach of the community, for example engineering structures upstream, are influencing the occurrence of flooding here. It is at this stage that you realise that you need to seek some advice upon which information is available and can be utilised for your purpose. The next section explores how to access this information.

## Section 2: Access to scientists and availability of data, information and knowledge

**Integration can only be successful if usable, credible and context relevant science is available and accessible. Whether you can find the information and whether the information is fit for purpose will vary according to the nature of the problem being addressed and the country where it is being applied.**

**There are a number of opportunities through which you and your organisation may access science, ranging from accessing information that is readily available (e.g. on the internet) to establishing a formalised partnership with a scientific organisation. The level of engagement will depend upon the context of the problem being addressed; however we advocate the use of partnerships as a key mechanism for delivering the scientific information to those who most need it. It is important to recognise that engaging with science does not necessarily involve new research; there is an abundance of existing information and knowledge that could prove useful to NGOs and communities.**

**-----------------------------------------------------------------------------------------------------------------------------**

- *What level engagement with science will help address the problem?*
- *Does your organisation already partner/work closely with a university?*
- *Do you know where the sources of science are within the country you are working?*
- *Have you conducted a power analysis of science sources?*
- *Is the available scientific information suited to your purpose?*

### *Open-source materials*

In the first instance, you may look for whatever science there is to hand through open-source[11] materials, such as websites, reports and some academic journals. **The analysis of secondary data**[12] is a necessary preparatory step in participatory capacity and vulnerability assessments (PCVA)[13]. This being the case, there may be a number of relevant sources of information including:

- **Maps**: hazard, vulnerability and risk maps; land use maps; geological maps; conservation maps (e.g. native species mapping), etc.
- **Risk assessments** e.g. national geological survey reports
- **Online databases** e.g. EM-DAT http://www.emdat.be/
- **Environmental information** e.g. water quality, deforestation, land use, etc.
- **Historical records** e.g. historical narratives, databases of previous disasters; information on previous agricultural techniques and mitigation methods

**The benefit of open-source materials** is that they are free and often quick to access – useful under time constraints and limited resources. The drawback is that it is up to you, as the user, to assess the credibility of the information available. Scientific information published in academic journals is subject to peer-review, in other words assessed for its credibility and robustness by other scientists. Not all the information online is subject to such scrutiny and some may reflect the opinions of those writing it, rather than having any factual basis. Many of the reports available online are classed as grey literature - information produced by government, academia, business and industry and NGOs in both print and electronic formats that is not controlled by commercial publishers (i.e. where publishing is not the primary activity of the producing body)[14]. It is also necessary to determine whether the information is suited to purpose and it is important to be aware that:

- Information may not be at the **appropriate geographic scale** – maps may exaggerate or 'hide' local differences in (for example) poverty levels; the data used to create the map may be *coarse* (limited data averaged over large geographical areas) that is impossible to *downscale* the information to the community level e.g. national or global scale maps.
- Data, maps or models may be **out of date**. Scientific understanding is advancing constantly and sometimes these advances can be significant. It is therefore important to try to ascertain when the information was developed.
- There may be a requirement to convert the **science into non-technical language** in order to communicate it to other stakeholders, including the community.
- The most readily available, understandable and **attractive information may not necessarily be the best**.
- You need the knowledge and skills to assess whether the information available is **credible** (see section 3 for credibility).

[11] Information that is freely available compared with information that must be subscribed to (e.g. a number of academic journals).
[12] Primary data is collected and analysed by you, whilst secondary data is collected by others examples of secondary data sources include newspapers, journal articles and other publications.
[13] For example ACF's Participatory Risk, Capacity & Vulnerability Analysis
[14] Schopfel J. and Farace D.J., Grey literature. In: Bates M.J. and Maack M.N. (eds.) *Encyclopedia of Library and Information Sciences*. 3rd ed., London England: CRC Press; 2010:2029–2039.

*Asking a science expert*

Knowing who to ask may not always be obvious but there are a number of organisations local or international that may be able to provide expertise:

| | |
|---|---|
| Local observatories | • e.g. volcanic, seismic and meteorological |
| Geological surveys | • e.g. mapping and environment agencies |
| Universities | • e.g. geology, geography, engineering, earth science departments |
| National or local government | • e.g. scientific and technical departments, social welfare departments, disaster management offices/office of civil defence and extension services |
| Environmental, conservation and engineering NGOs | • e.g. local organisations or technical specialist organisations |
| Private sector | • e.g. insurance companies |
| Professional societies | • e.g. accredited academic and practitioner networks |

Initial consultation with an expert is likely to be informal, and dependent on your and their availability. You should be aware that there are differences in partnership approaches between those scientists work within a university (often referred to as academics), and those who work for institutions (public and private) such as national meteorological agencies or geological surveys. Differences include but are not limited to institutional or personal reputations, approach to taking on new work, contracts and administrative requirements, and flexibility. Whilst some scientists may be happy to engage others may not because of:

- a lack of time (or not timely enough);
- a lack of willingness to engage (not willing or able to share information);
- a reluctance to engage owing to concerns over whether they may be held accountable for use/misuse of the information they provide;
- a lack of understanding of how they can communicate their science.

**The capacity and knowledge of local scientists** will vary from country to country. Politics can influence the integrity of scientists, how science is used and whether it is made available; corruption and bias within science can pose a challenge, and in some contexts it may not be possible to work with local scientists in government or academia or to trust them or the information they provide. It is recommended that NGOs **conduct a power analysis**[15] **of science** to help determine levels of corruption and power dynamics that could affect the credibility of the available science.

Asking a science expert is useful for more ad hoc engagements, particularly when relying upon existing information and knowledge. However you may identify the need for information to be tailored to support a specific project or decision making process or new research in order to address

[15] For information on power analysis in general, please refer to the World Bank's PSIA Sourcebook.

the problem (e.g. the study of water availability, quality and management across a watershed shared by a number of communities). In these instances, you may decide that a formal research project is required.

### *Collaborative research projects and formal partnerships*

In instances where research is required, it is essential to adopt a collaborative approach that includes the participation of all relevant stakeholders. The benefits of a collaborative research project include:

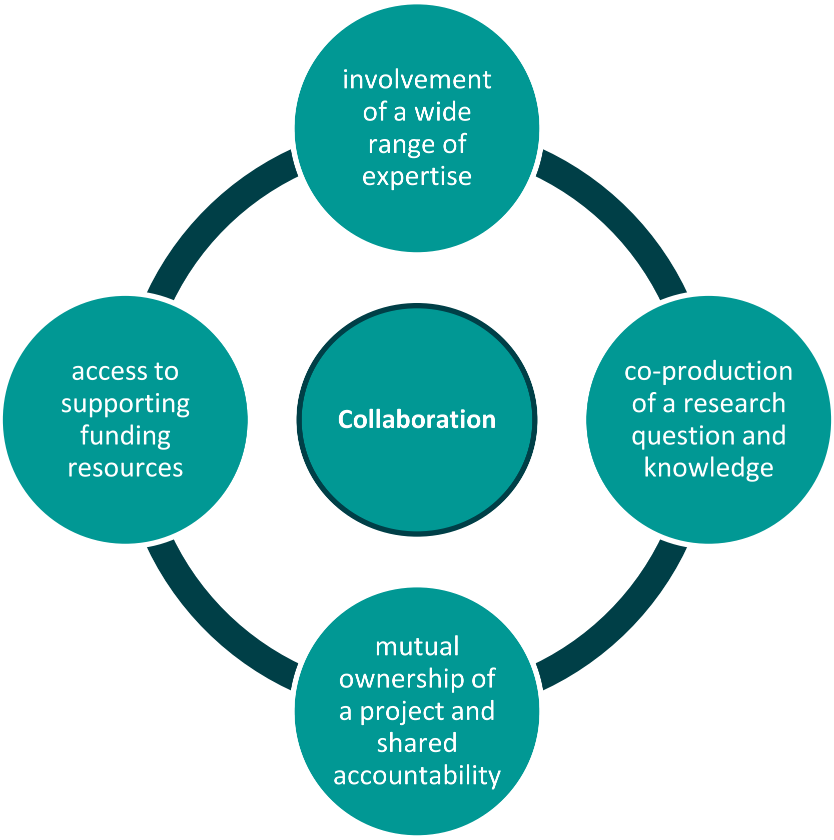


**Figure 5: Some of the benefits of collaborative projects.**

**The objectives, ways of working and value systems of science and scientists may differ from those of humanitarian agencies** (e.g. the primary objective of scientists may be the advancement of that science rather than the reduction in vulnerability). Clear and frequent communication is essential to the success of any collaborative research project, along with co-created and shared learning. Where appropriate, collaborative research projects should adopt the principles of participatory action research, meaning that those who are researched should be involved as equal partners in the process[16].

Short term engagements may be difficult to sustain as they may rely upon the good will and available time of the scientist (except in the case of paid consultants). It is important to consider a long term relationship between organisations rather than individual relationships to ensure the institutional memory of science.

[16] Institute of Development Studies (IDS). Participatory Methods: Research and Analysis. Available online: http://www.participatorymethods.org/task/research-and-analyse

Engaging with scientists should not necessarily be a one off process and there is growing evidence to suggest that the successful delivery of science is through formal partnerships with scientists (see case study 2: UCL-CAFOD partnership). Partnerships may begin informally, for example building upon initial consultations with experts or nurtured through previous colleagues who have moved from academia to an NGO (or vice versa), but these necessitate a degree of formulisation in order to **ensure accountability** and **protection to all stakeholders**.

In addition to the benefits of collaborative research outlined above, the benefits of a well-established partnership include:

- access to a greater range of expertise beyond your initial contact;
- opportunities for capacity building;
- long-term engagement to support sustainable projects;
- rapid access to knowledge and expertise in response to short deadlines;
- the development of mutual understandings, agendas and language.

As with any partnership, project design, learning and knowledge production should be mutual; whilst scientists can contribute a lot of knowledge and research, NGOs have vast experience and communities can share their knowledge of the risks they face.

Partnerships should also be inclusive of all stakeholders, engaging (where possible) with local scientists and other relevant actors to encourage long-term sustainability within country and to avoid any possible conflict. However, there are often numerous challenges to conducting scientific research in developing countries, from limited material and financial resources to poor infrastructure[17]; as such, the type of partnership may also reflect the circumstances of the country in question.

Christian Aid has established a successful partnership with a local scientific organisation in the Philippines[18]; and in the Eastern DRC, NGOs have consulted the Goma Volcano Observatory which operates in challenging conditions but is supported by international scientists:

**Top tips for partnerships with scientists:**

- Partnerships may not just be about the people who are the easiest to work with – they are also about gaining access to those with the best information;
- Often the necessary scientific expertise will vary depending on the nature of the problem being addressed; although the entry point to a partnership may be through an individual in the long term it is **advisable to partner with an organisation**, whilst also having an organisational lead on the partnership within the NGO and the scientific organisation, each of whom can facilitate linking practitioners with the relevant information and expertise;
- It may be better to deal with institutions rather than an individual as the work will be viewed as an official assignment and **allocated appropriate expertise and time;**
- Partnerships take time, commitment and long-term engagement and all stakeholders need to be aware that results may not be immediate;New research projects can take several years to deliver and scientists are constrained (in the same way NGOs are) by their institutions and the demand of their day to day job.

[17] Harris, E., 2004. Building scientific capacity in developing countries, European Molecular Biology Organization Reports, 5 (1), 7-11.
[18] For an example of their work see *Big River Rising,* http://www.preventionweb.net/english/multimedia/v.php?id=29335&hid=62

*"The local volcano observatory faces numerous challenges but is able to maintain its monitoring and outreach capacity partly thanks to the support of some international scientists. Services that have been developed from international scientific research projects include provision of near real-time 24hr automated satellite remote sensing products which enable the observatory to advise on the status of the volcano even if ground monitoring equipment is compromised."* ***Dr Susan Loughlin, British Geological Survey.***

Some of the barriers preventing NGOs from partnering with scientists include:

- a lack of funding for collaborative research;
- a lack of capacity (particularly in-country);
- a differing aims, objectives and ways of working;
- knowing who to believe amongst scientists with differing opinions;
- a nervousness amongst scientists about willingness to engage (e.g. with regard to their accountability);
- the long-time scales of carrying out research;
- a differing technical language between NGO staff and scientists.

Before succeeding in partnership, it is necessary to address the different objectives and perspectives across the scientists, NGOs and communities, as well as:

- Address any concerns you might have over **the economic and social sustainability** of the possible applications of science.
- **Question the track record** of the science they are resourcing – has it been used before successfully in a similar context? Is the skill of predictive science good enough to use for forecast-based decision-making at community level? Will scientists be open about potential negative impacts of applying their science? Do conflicts of interest exist (e.g. corporate scientists pushing their employers' products)?
- Combine focused scientific expertise with broader, multifaceted development objectives in order to **ensure that the scientists serve the development objective**, rather than the other way around. The scientific agenda is significantly influenced by what policymakers want but much less so by what vulnerable communities may want.
- **Match the available scientific expertise with the problems** that need to be addressed from the community perspective, e.g. there may be significant scientific expertise on large-scale flooding but little on recurring, local flood or waterlogging risk.

Whilst there are a number of challenges to establishing partnerships, there are an increasing number of opportunities for funding, including joint funds for large consortium programmes, co-funded research projects and funds for project evaluations[19]. The **Enhancing Learning and Research for Humanitarian Assistance (ELRHA) Guide to Constructing Effective Partnerships** is a useful tool for deciding whether a partnership is best approach for your agency and how to go about establishing one. It is also a useful resource for those wishing to establish a collaborative research project with a scientist or institution.

[19] Two UK funding bodies with a recent interest in partnership are the NERC and ESRC (please refer to the reference list for their website addressed).

**Case study 2: Academic-NGO partnership – reflecting on the partnership between University College London (UCL) and the Catholic Agency for Overseas Development (CAFOD)**

*The partnership between UCL and CAFOD began in 2008. It was born out of informal discussions between acquaintances within the respective organisations and rapidly grew into a formal partnership with the signing of a memorandum of understanding (MOU). The founders of the partnership recognised the need and opportunity for rigorous analysis and research, particularly in the natural and environmental sciences, to underpin humanitarian and development policy and practice in disaster risk reduction, adaptation to climate variability and natural resource management[1]. In addition to knowledge exchange activities, including field visits to examine in-country risk.*

*By the end of 2013 the partnership had appointed one post-doctoral research fellow and three PhD students to research projects, some of which have attracted funding from the UK Engineering and Physical Sciences Research Council and the Natural Environment Research Council. The projects are based on sound scientific research that will have impact within CAFOD, its partner organisation and within communities, by informing policy and practice. Three of the projects are co-funded by UCL and CAFOD and all were co-developed and are co-managed by UCL, CAFOD and CAFOD partners.*

*For CAFOD and its partners this partnership provides access to some of the world's leading experts in natural hazards, natural resource management, climate change and disaster risk reduction, in addition to data, information and knowledge not normally accessible to NGOs. For UCL the partnership informs research, teaching and knowledge exchange, and enhances the training of early-career researchers. For both organisations the partnership has led to new relationships with universities in the countries where projects are focused, which has enhanced the capacity of these universities to perform and apply scientific research. More generally the partnership is regarded as innovative and pioneering as an example of best practice in the integration of science for humanitarian and development benefit.*

*The collaboration has also produced important generic learning on partnerships:*

- *meaningful and effective partnerships take time to build, necessitating the allocation of staff time by all organisations involved, and there is often a significant period of sympathetic learning and understanding required before projects are agreed and set in motion;*
- *collaboration between universities and NGOs has to take into account their significant differences, which include ways of working, types and timescales of deliverables, contractual requirements, depths of analysis required in projects, and expectations of donors, funding bodies and partners.*

## Section 3: Understanding science and assessing its credibility

**Every day you are confronted with arguments that demand logical, ‘scientific’ reasoning. Understanding and assessing the credibility of science is no different and this section provides a pathway through the maze of facts in order to separate the credible from the suspicious[20] so that you can make sensible and informed decisions.**

---

- *Do you/the community understand the information?*
- *Do you have confidence in the information?*
- *Is the information relevant to the problem you want to address?*
- *Do you know if there is uncertainty?*
- *Have you asked the scientist why there is uncertainty?*
- *Have you reviewed the credibility of the information you are using?*
- *Are you consulting with a credible scientist?*
- *Is the information good enough for your purpose?*
- *Are you convinced that the science is free from any conflicts of interest?*

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Even when accessing and applying science through a partnership, it is necessary for practitioners to have a basic understanding of science in order to know:

- What questions to ask of scientists?
- Whether the data/information appears to be credible?
- How to communicate the science to communities and other stakeholders - you may have a role as an intermediary in the communication of science, facilitating the bringing together of communities and scientists and communicating scientific information when scientists are unavailable?
- What to monitor and evaluate in terms of the impact of science?

[20] Scheaffer, R. and Young, L., 2010. Introduction to Probability and its Application. Brooks and Cole.

The process of integrating science is not simply about science informing NGOs who, in turn, use this information to assist communities; there is evidence to suggest that community members can benefit greatly from direct exposure to scientific information if it is properly communicated and the community receive some accompanying education (see case study 3):

The provision of a comprehensive scientific training is beyond the scope of these guidelines; however a number of key concepts are discussed below.

### *Qualitative versus quantitative*

When combining natural and social sciences, let alone applying these to humanitarian and development planning and practice, debates often emerge around the respective roles of quantitative and qualitative data collection and analysis. Some problems are suited to both approaches, while others to one or the other. The term quantitative refers to information based upon measurable amounts that can typically be recorded numerically (e.g. the level of water in a river). Qualitative research deals with problems that are not measurable, and usually emphasises 'words' (descriptions) rather than counting in the collection and analysis of data[21], for example an historical narrative of a community member's experience of living by a river that floods. Both are essential to the integration of science for building resilience. Often quantified results are a helpful means of building baselines for monitoring and providing evidence to advocate for change. Qualitative methods are especially helpful when trying to determine the less tangible causes of vulnerability and risk, for example communities' perceptions of risk and the decisions and behaviour they adopt in the face of it.

### *Quality*

In many of the countries within which you operate, there are likely to be issues relating to data availability and quality. If understanding science is not challenging enough, then appreciating the quality of data perhaps presents an even greater challenge. **Data quality refers to the resolution, completeness, precision and accuracy of the data.** Assessing the quality of data necessitates looking at:

- **Methods of collection:** these should follow internationally recognised protocols and principles of the scientific method;
- **Resolution:** how concisely and thoroughly defined the data are – a low resolution map may have hazard, vulnerability or risk averaged over large areas that hide the true picture risk at the local level;
- **Completeness:** whether there are any (unexplained) gaps in the data; unless a thorough baseline has been collected, it is more than likely that there will be gaps in the data record so it is important that the science you utilise mentions whether the data are incomplete;
- **Precision:** how close the data is to being exact (e.g. 2.95 is more exact than rounding up to 3). This has important implications for the reproducibility of a study. It is also important to note that precise data are not necessarily accurate;
- **Accuracy:** how close the data is to the truth. Methods to measure accuracy include taking into account how old the data are (e.g. earthquakes recorded prior to the late 1800s will be

[21] Bryman, A., 2008. Social Research Methods. Oxford.

based upon descriptive historical records, rather than technical readings from seismographs); any bias in the data (in terms of how it was measured); whether it has been consistently and validly recorded (especially when different data sets are brought together).

***For practitioners the main question should be is the information is good enough for the purpose at hand?***

### *Credibility*

The **credibility** of scientific information reflects the extent to which the information is believable or convincing; in other words if the information is a realistic representation founded on the data upon which it is based. A relevant example is the *skill* of forecasts, i.e. how well the forecasts match observations.

Practitioners need to be able to trust the information they are using in order to be accountable to donors and beneficiaries. There are mechanisms for ensuring that science is credible; for example, most published scientific work has been peer-reviewed, which means that is has been scrutinised by other scientists who have assessed its quality and ensured that is has met a minimum standard.

The difficulty is that much of this peer-reviewed literature is not freely available and it is mostly intended to be read by other scientists who are very familiar with the topic of the publication. Consequently, most scientific literature is inaccessible to the non-specialist. For this reason, there is a growing emphasis on knowledge transfer or exchange experts in the scientific community, whose role is to make the science useful to a non-specialist end-user. Despite this move, the uptake and application of science by NGOs is still very limited and more effective mechanisms need to be found to improve this.

We have to consider not only the credibility of the information but also that of the scientist. As noted in section 2, the integrity of scientists may vary, which raises a number of additional challenges you should be aware of in order to ensure that the science you use is credible:

- **Scientists do not always agree** and it may not always be obvious whom to believe so try to weigh up the balanced arguments, taking into account the uncertainty of the information presented.
- **The scientist needs to be qualified** in the problem being addressed.
- **Science and scientists may be manipulated for political gain**, again emphasising why it may be necessary to do a power analysis of science.
- **The way data are presented can affect their credibility**, e.g. by exaggerating results or hiding the reality of the situation – you will rarely find a map with blank spaces representing missing data. To ensure that the data are credible it is necessary to ask scientists where the data came from or, if this is not possible, see if the work refers to the source of the data and whether it gives the date when it was published.
- In instances of data incompleteness, conclusions and **recommendations may be based upon expert judgement**, which is fine as long as the scientist has been honest about the

uncertainties and is clearly knowledgeable in the aspect being considered. It is, therefore, necessary to look at what has informed the scientific information you plan to use.

- **Ultimately some studies will be based upon more data than others** – credible studies will outline how much data they have used and the extent to which this limits the conclusions that can be made, others might not, so using some judgement can help.

| Top tips to check credibility |
| --- |
| *Use more than one source of information/expertise.* |
| *Beware of information freely available on the internet - use only reputable sources.* |
| *Where accessible, use science published in peer-reviewed journals.* |
| *Use accredited (recognised) institutions or experts.* |
| *Ensure that an explanation of the uncertainty of the science is included.* |
| *Consider the amount of and quality of the data consulted.* |
| *Conduct a political/power mapping tool of science for the country of interest.* |
| *Where the science disagrees, consider the majority of opinions rather than the extremes.* |
| *Reference and date your work (and ensure the scientific information you use is too)* |
| *Review how much (and the quality of the ) data was used to create the information you want to use.* |
| ***IF IN DOUBT – SEEK ADVICE*** |

### *Uncertainty and probability*

**If uncertainty can be better understood, appreciated and harnessed, then the opportunities and limits of utilising scientific information can be more effectively realised**.

Few findings from natural and social science are 100% certain[22], owing to the fact that data and information are often incomplete and that scientists' understanding of processes is incomplete. In spite of this, we still have to make decisions for building resilience. In the case of data and

[22] Scheaffer, R. and Young, L., 2010. *Introduction to Probability and its Application*. Brooks and Cole.

information that are not certain, they should be presented with the degree of probability or likelihood indicated. In general, probability can be defined as the chance that something will happen or that a statement is true. Predictive science (e.g. weather forecasts) is probabilistic and, as such, does not give a definitive certainty but instead a range of probabilities that need to be understood and managed.

Practitioners should not be apprehensive of using information that is uncertain so long as any decisions and actions based upon the information are made with a full understanding of the associated uncertainty and its implications. It should be remembered that uncertainty will usually promote an analytical debate that should lead to robust decisions, which is a positive manifestation of uncertainty. **Facilitating a dialogue between stakeholders on science and its uncertainty is part of an essential process for better decision making**[23]. Credible scientific information will also have any associated uncertainty clearly presented.

**Decisions should be informed by more than one information source and any uncertainty should be clearly communicated so as to ensure accountability.** It is important to be aware, however, that the provision of additional information can also increase (as well as decrease) the uncertainty.

It is essential to manage the expectations of the recipients of science by **clearly communicating the uncertainty and limits of the scientific information being provided in an understandable way**. The following case study addresses the application of probabilistic information in the context of climate science.

“

***Natural sciences are not exact because of data sampling, area representation, and limited number of monitoring stations. As monitoring points increase the 'facts' are likely to change***

Ayub Shaka Kenyan Meteorological Dept

”

[23] Visman, E., 2014. *Knowledge is power: unlocking the potential of science and technology to enhance community resilience through knowledge exchange*. Humanitarian Practice Network Paper Number 76.

**Case study 3: Increasing Access to Climate Science for Small-Scale Farmers in Kenya**

*In Mbeere District, Kenya, Christian Aid supported local partner Christian Community Services Mount Kenya East (CCSMKE) to increase access by small-scale farmers to seasonal forecasts and short-term weather forecasts. The basic hypothesis was that better use would enable better decision-making which in turn could result in a yield increment of 10-20%. The first step was to get the forecast from the Greater Horn Regional Climate Outlook Forum and organise training for implementing staff and farmer group leaders, who could then relay the scientific information together with agricultural recommendations back to their wider group membership. Through an exchange (coordinated by the Humanitarian Futures Programme at King's College London) scientists from the Kenya Meteorology Department (KMD), the UK Met Office and the University of Sussex were involved in the initial training, with CCSMKE staff and local Ministry of Agriculture advisors providing follow-up and organising other channels of information, such as a text messaging service for the 7 day forecast through the season.*

*The project was acutely aware of the need to consider farmers' own beliefs, values, motivations and perceived control. Without this, efforts to increase use of science for decision-making based on the pursuit of scientific education alone would be unsuccessful. So the training covered a variety of aspects of the climate science involved as well as exploring how local indicators could be combined with the forecast. This and understanding how farmers have responded to climate variations in previous seasons added contextual information to facilitate farmers making climate-smart decisions for the upcoming season.*

*Although the KMD forecast is released in a deterministic format, farmers were provided with the probabilities and training in how to interpret it. Concerns about forecast reliability were addressed by explaining how forecasts are compiled and how often they had proved accurate in the past (about 80%, so 4 seasons in 5 are successfully forecast). This was a concept familiar to farmers since they apply different levels of reliability and usefulness to their own indicators. Those used by farmers were focused primarily on when the rains would start, although their use was assessed as having declined in recent years. This was partly due to modern education and religious influences but mainly due to the loss of some local indicators, e.g. certain tree species traditionally used for forecasting, as land is cleared for agriculture and other uses. Initially farmers expressed reservations about the usefulness of forecasts, perceiving that they were only relevant to neighbouring districts with climate stations but not to their own, drier situation. The 7 day forecast was therefore tailored to reflect this concern for local relevance. The compatibility between local indicators and the seasonal forecast, which gave information in addition to the onset date, was also made clearer.*

*Measuring the impact of the work over two seasons followed a basic evidence chain to get to an understanding of how enhanced use of forecasts might deliver the initial hypothesis (figure 5).*

*Farmers confirmed that the advice they received was relevant and had largely been communicated effectively, although they also provided clear recommendations on how this could be improved.*

*They valued direct training with a scientist most highly but recommended improved use of radio, barazas (local meetings) and mobile phones (through text messaging).*

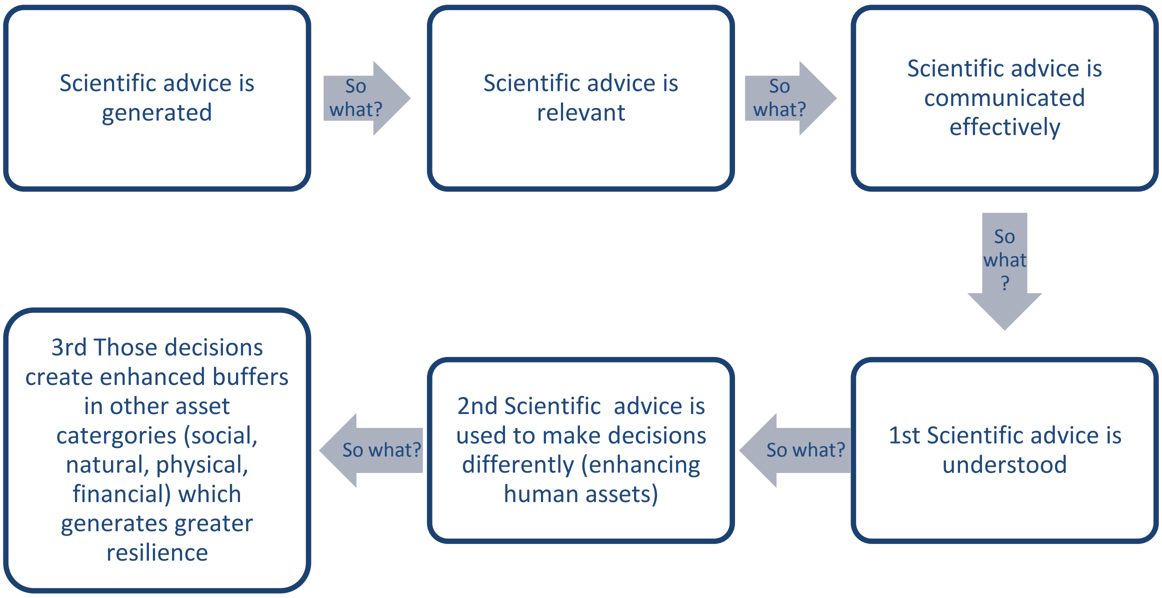



**Figure 6: Basic evidence chain for the impact of climate science in the context of small-scale farmers in Kenya.** Source: Richard Ewbank, Christian Aid (2013).

*Their understanding and use for decision-making was demonstrated through their feedback on decisions they had changed as a result of receiving forecast science. These included (in order of importance):*

1. *changing the planting date*
2. *planting drought-resilient varieties of their usual crops*
3. *planting more drought-resilient crops*
4. *changing to conservation agriculture techniques to conserve soil moisture*
5. *improving the timing of on-going operations, such as fertiliser application and pest control.*

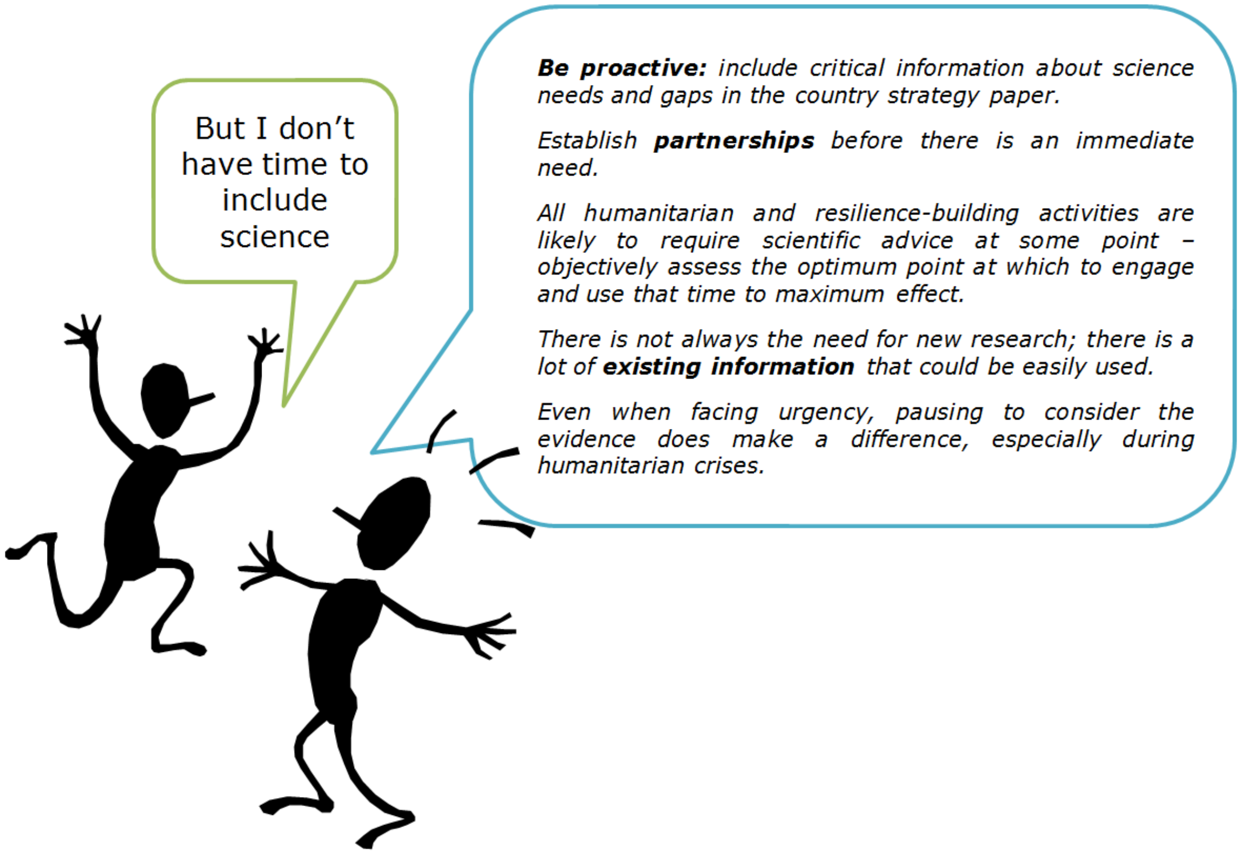
*As a result, 96% of farmers reported an increase in yield due to improved decision-making based on forecast use, and about two-thirds assessed the increase as in excess of 15%. Given this result, farmers felt the best way forward included KMD establishing a climate station in their district to measure climate but also provide advice, forecast training and support to assist farmer groups establish their own rain gauges. This would expand the network measuring key climate variables, engaging science users in the generation of improved science, and also facilitate a sustainable link to the sources of climate science support.*

### *Training and skills development*

This guide has thus far shown that it is essential for NGOs to build a certain level of in-house understanding of science, so that NGO actors may act as effective intermediaries in accessing scientific information and resources, using them, and transferring them on to their partners and the communities within which they work. There are two effective mechanisms for achieving the necessary increase in understanding, which have been effectively demonstrated by the (re) insurance sector over the past 15 years:

(1) employ more scientifically trained staff and
(2) train existing and future staff in the necessary skills to engage with and use science

Both of these should also lead to more partnerships with scientific organisations. Unfortunately, building scientific capacity within NGOs is a challenge because of the need to minimise what donor and other sources of funding refer to as overheads, into which scientific capacity may fall. This challenge has to be overcome if understanding and using science is not to become yet another element of rhetoric. To this end, training is a relatively quick, simple and cost effective way of introducing meaningful numbers of NGO staff to science and the scientific method in order to improve their scientific literacy, skills and confidence. Such an approach should be linked to initiatives to professionalise the humanitarian and development sectors within the UK and elsewhere.



## Section 4: Applying scientific information and methods to humanitarian and development work

**The sections described so far have looked at defining the problem to be addressed and the reason for integrating science, how it might be accessed and what sort of information might be available, as well as some basic insight into understanding science and being able to assess its credibility. All of these have to be considered when applying science. In order to apply science, it is necessary to present information so that it is understandable and, therefore, enables users to make informed decisions. The application of science is iterative and involves learning and adapting in light of new information that may become available.**

**In this section, we discuss not only the application of scientific information but also the use scientific methods for collecting, analysing and presenting data. Suggestions are also made as to how to manage the process of integrating science in an ethical and accountable manner.**

- *Do you know when to include the science?*
- *Do you know what scientific methods could help?*
- *Have you discussed accountability with the scientist/source of information?*
- *Have you ensured that the information users have the right tools and capacity to manage uncertainty?*
- *Have you ensured that information users have a clear understanding of the credibility of the science?*
- *Have you spoken to the scientist about any ethical guidelines they have to adhere to?*
- *Are you and the community aware of the levels of confidence and uncertainties of the information you are using?*
- *Have you combined the relevant sources of scientific and other technical expertise with what advice on what to do?*

*Opportunities for applying science*

Table 2 outlines some examples of where science can be integrated into existing strategies and programmes at varying scales.

| Level | Scale | Application |
|---|---|---|
| International/strategic | Regional | Country prioritisation<br>➢ Multi-hazard assessments in order to prioritise strategic interventions. |
| Programme | National | Country strategy paper<br>➢ Evidence of existing and future risk<br>➢ Data with regard to past risk<br>➢ Quantifiable risk |
| | Sub-national | Natural resource management<br>➢ Remote sensing<br>➢ Environmental impact analysis<br>Human displacement<br>➢ Expertise in health and shelter |
| Project | Local | Local level assessment, e.g. content analysis (hazard, vulnerability and capacity), needs assessment, livelihoods analysis<br>➢ Use scientific information to complement local knowledge<br>➢ Use scientific expertise to interpret change seen at local level<br>Early warning system<br>➢ Threshold for triggering the warning system |

**Table 2: opportunities for integrating science**

Of particular interest to NGO practitioners is the application of science at the community level and whether this information can be transformed into something that is understandable and useful to the community. Examples of where science might be applied are listed below.

**1. Participatory vulnerability and capacity assessments** should incorporate scientific advice in the risk assessment and community planning process:

- **During pre-screening of risks** (largely top down, where scientific advice can give an NGO guidance on the key issues to address in a particular region or locality);
- **By bringing together community-based mapping with similar scientific processes**, such as GIS mapping, to develop accurate participatory maps of risks and vulnerabilities;
- **During event timeline development**, where the perceptions and recollections of climate, geophysical and other events are triangulated against the scientific record to accurately establish past and identify potential future trends;
- **During the action planning -** an interactive and iterative process at the community level. Local knowledge can provide local specificity and context to enable more specific scientific advice to be guided by the priorities as expressed by the community, information users, etc.
- **By guiding the revision of community-based plans**/repeat PVCAs as new scientific information is developed or new risks and stresses amenable to scientific solutions/mitigation emerge.

**2. Training and education**: science-based field schools e.g. climate field schools that bring user groups together with climate scientists in a series of training sessions over a specific period of time to enable better integration of short, medium and long-term climate science into community or group-led resilience and development processes.

**3. Participatory research**: where scientific research and advisory services are based on diagnostic studies of community-prioritised issues and challenges rather than those of the scientific/policy-led bureaucracies. Research is likewise based in the community (e.g. participatory research involving farmers) rather than in isolated research environments. There is a need to ensure that community interaction and consultation is designed to identify challenges, issues and opportunities that could benefit from subsequent support by scientists.

In order to explore this further, let us look at a fictional scenario of building flood defences for a community living close to a river:

*The community are regularly affected by flooding. The local people have good knowledge with regard to the flooding but this is based solely upon their recollection rather than any systematic monitoring of the flooding. They have no memory of a large scale flood and there is a proposal to build flood defences by the banks of the river in order to protect the community. The heights of these defences are based upon the flood height as described by the community. They indicate that the flood waters rose to their knee height.*

**Figure 7: Local communities examining flood waters in Xai Xai town Mozambique February 2013.** Source: Laura Purves, CAFOD.

*There are two reasons why science needs to be applied:*

1. *In order to check (triangulate) the communities' knowledge with additional information and knowledge.*
2. *To establish a more systematic method of determining the height of the flood defences, as flood heights (even during the same event) can differ from place to place. Obviously you can take an average of what the community indicate as the height of the flood but this omits the fact that some may have been standing in dips or at raised points at the time of the flood. As such, their memory of the flood height may not be*

*representative. Flood depth can change depending on whether the height was measured at the peak of the flood or when the waters had begun to recede.*

*You are able to find support from a local hydrologist (a scientist who specialises in water and geology) who has actually done some mapping of large-scale flooding in the area – they are able to:*

- *Demonstrate the flood height of a much larger flood that occurred 70 years ago.*
- *Assign a return period (inverse of probability) for a flood of this height to occur.*

*Based on the additional scientific information, the community decide to invest more in their flood defences and build them higher. However, the hydrologist points out that the proposed flood defences are unsuitable as they are likely to increase the risk of flooding to downstream communities. He speaks to a colleague who is an engineer who suggests a more appropriate measure of drainage and improved land use planning.*

*Given what you and the community have learned from the hydrologist, you decide that this is a good opportunity to improve the communities' understanding of flooding in their region and establish a baseline of data regarding flooding. The community, therefore, establish their own monitoring system:*

- *Volunteers from the community to be flood monitors are given a camera, map and mobile phone as well as training on the health and safety of measuring the height of the flooding as well as where to take regular measurements of the river level (and after periods of heavy rainfall) from a set of predefined points;*
- *The hydrologist teaches the volunteers about different types and sources of flooding.*

*As a consequence of engaging with the scientists, the community soon discover that the reason for the increased magnitude of the floods is attributable to surface water flooding (combined with that from the river) because of a new road the local government recently built through the town that is preventing the water from draining away. The baseline of information collected by the community is regularly shared with the hydrologist who helps the community establish an early warning system for certain types of flooding. A low cost rain gauge based warning system for surface water flooding is also funded.*

**This scenario highlights two important points:**

1. Scientific opinion and information may disagree with what the community and/or NGO would like to do (e.g. flood defences were in appropriate). Such a situation needs to be well managed and changing attitudes can only come about if people have complete trust in the science they are using;
2. Scientific methods of monitoring and recording data can assist with increasing resilience and empowering communities to better understand and take ownership of their own situation and establish 'community scientists'.

Despite a tendency to polarise the views of scientists and local communities, they can very much learn from one another. Communities, if adequately trained and capacitated, can be invaluable in the systematic collection of data regarding hazards and risk, which can be interpreted by scientists to inform strategies for increasing resilience[24].

Community knowledge can often be the only immediate information available and by ensuring that it is systematically recorded and (as far as possible) bias removed, baselines can be established. By applying good scientific procedures to ensure the quality of the data being collected the information produced will be more robust. Simple techniques to ensure data is well recorded include:

- Having a **consistent approach to when and how often to record** information and take measurements.
- Knowing to take these **from the same, predefined point** (or persons to compare interviews over time) in order to create a baseline and capture subsequent changes.

Educating communities on how to measure their own risk scientifically should help to inform their decision-making and also internalise the science that is being presented (see Case study 4).

### *Managing stakeholder expectations*

The process of applying scientific information relies upon good communication and continual discussion that challenges and reviews of all the available information throughout the process. Where community knowledge contradicts the science (or vice versa) it is important to engage a participatory dialogue, whilst also triangulating any other available sources of information.

In general, experience has shown that communities are amenable to outside information, even if it contradicts their own. There may, however, be resistance to the science from the community, who may not be willing to accept or take appropriate actions based on the results. It is not only necessary to know where and when to bring in science but also who to target – some community members may not be willing to engage with scientists (and vice versa), whilst others may be more open to listening to this information (see case study 5). In order to help manage the process of integrating science, engagement with science should not be a one off; it should be maintained throughout the project.

Scientists are also limited in their time and availability, often due to factors beyond their control (e.g. institutional (funding) constraints) and their willingness to engage with NGOs may be because of a desire to do so and not necessarily because they are incentivised to do so by their institutions. It is important that NGOs are mindful of this, especially if frustrations develop over the immediate availability of the scientists. Likewise it is necessary to ensure that scientists are aware of the resource and time constraints upon NGOs and the communities they assist.

However, arguably it is through well-established partnerships that some of these potential conflicts can be surmounted; by having a key contact within a university, information may be more quickly acquired. **Establishing formal partnerships enables the development of Terms of Reference – agreement on what to expect, what not to expect and any resource sharing to facilitate enhanced scientific support.**

[24] The Big River Rising Documentary is available online http://www.christianaid.org.uk/whatwedo/in-focus/big-river-rising/background.aspx

**Case study 4: Citizen Science in action**

*In flood prone Malawi, Christian Aid with local partner Evangelical Association of Malawi brought together community members from Village Civil Protection Committees with scientists from the Department of Climate Change and Meteorology and District Council staff responsible for water management and disaster risk reduction. This enabled:*

- *Flood risk mapping*
- *The development of an action plan and implementation of flood mitigation measures.*
- *The calibration and correct siting of river level gauges, with an easy-to-read traffic light system to facilitate early warnings.*
- *The establishment of community-managed rain gauges to enable them to supplement this system and their local indicators with their own data recording for water and drought management.*

***The Chikwawa community in Malawi check their own rain gauge as part of their flood monitoring system.*** *Source: Richard Ewbank, Christian Aid*

**Case study 5: Integrating science is more than just the provision of information**

*In February 2006, a major landslide buried the barangay (village) of Guinsaugon in Southern Leyte, Philippines. Shortly afterwards, technical investigations were made of nearby slopes to determine the risk to adjacent communities. Below is an extract from 'From Catastrophe to Opportunity: Children in Asia creating positive social changes after disasters' (page 50-51), which describes the actions Plan Philippines' and the community took based upon the available scientific information and the resistance they experienced from some members of the community.*

*The Mining and Geosciences Bureau* [MGB] *in the Philippines Department of Environment and Natural Resources conducted a thorough technical study of the landslide-prone area and found that two villages were high-risk zones, as cracks in the mountains above could potentially lead to dangerous landslides. With this vital information, it became clear that those living in the threatened areas – one of which was Santa Paz – ought to take precautionary steps to prevent a disaster from occurring…*

*After the result of the bureau's findings, the children in Santa Paz made a significant decision. Their school was located below an area in the mountains considered to be hazardous, and they noticed that mud and rocks had fallen down near the school. After a minor mudslide occurred nearby, some students, under careful supervision, ventured up the mountain to investigate the situation. Once they saw the cracks in the mountain, they decided that it was indeed too risky for the school to remain in its location. The school children overwhelmingly voted to evacuate and the teachers agreed. Within 12 hours, Plan Philippines offered to provide temporary tents for the children to learn in. Plan also gave approval to build a school out of range of the landslide danger zone, and construction of their new school started shortly after...*

*According to Plan Philippines' DRR advisor, Baltz Tribunalo, "The adults' level of consciousness mattered in this process. While children were making their decision, teachers and other community leaders like the members of the Municipal Disaster coordinating Council and Plan frontline staff helped in the processing of their decisions and related consequences, and also contributed by facilitating and maintain the difficult but liberating decision."*

*The children's bold determination turned out to be controversial, as some parents were concerned that their children would have to walk more than an hour or longer to the new school. Other community members living near the old school were unhappy because it had been abandoned, and some criticised the children strongly for their decision to move. This upset the children, who felt that they were only looking out for their own safety… Despite the rift with some parts of the community, almost all of the children continued to attend the school in its temporary tent site from July 2006 to March 2007 and then moved in June 2007 into the new school. They were grateful to Plan for the new, safer school and the training they had received. "All students, as well as citizens in the country, ought to be trained in DRR," said a 16-year-old boy from Santa Paz.*

*There are a number of interrelated reasons (e.g. related to culture and day to day, livelihood priorities) why some members of the community chose to act upon the science whilst others did not. However, whilst the MGB conducted their technical study, which they shared with Plan Philippines, they appear not to have been involved in discussing this risk with the community. By properly communicating the risk and the associated uncertainty, they could have helped bolster the argument the students were making for relocation. The scientific information provided is only as useful as the quality of its communication.*

*Ethics and accountability*

If science is to be used to support planning, decision-making and practice then its **inclusion needs to be transparent and reflect the contribution of all stakeholders**. NGOs and scientists operate within different systems of standards and with different ethical expectations. It is important to be aware of the ethical frameworks under which scientists must operate and develop ways of managing areas where these frameworks may come into conflict with NGO approaches to accountability. You will need to consider how to approach co-production of knowledge in a manner that is consistent with principles of participation (a core component of accountability to disaster affected communities) in circumstances where scientists offer advice that is in conflict with the desires and views of the community.

There are systems in place to ensure the protection of participants in scientific research and UK academics must adhere to the ethical research principles of their institutions' and funders' ethics committees. Examples of the ethical frameworks for researchers in the UK include those outlined by the Economic and Social Research Council's (ESRC)[25] and the Natural Environment Research Council's (NERC)[26] regulations.

The ethical issue of particular concern is the fact that those who will ultimately benefit from the integration of science through the increase in their resilience and reduction in their vulnerability may also be the focus of the research study, however, the ideological perspective of action-research is that those who are researched need also to be involved as equal partners in the process.

With regard to ethics, it is important to be aware that:

- some natural scientists may be less familiar with the potential ethical impact of their research, owing to less experience of working with peoplecommunities
- local in-country scientists may not have the same systems in place to ensure ethical conduct
- partnering with scientists in the private sector may bring further complications, as the objective of a private company or even a local government may not align with those of a humanitarian agency

When conducting research involving people, scientists are mandated to[27]:

- obtain informed consent from participants
- maintain anonymity and confidentiality where appropriate
- adhere to regulations regarding data protection
- similar to NGOs, ensure no harm comes to participants and the environment
- give participants the right to withdraw from the study at any point

[25] ESRC Framework for Research Ethics. Available online: http://www.esrc.ac.uk/about-esrc/information/research-ethics.aspx
[26] NERC Ethics Policy. Available online: http://www.nerc.ac.uk/about/work/policy/ethics/
[27] Bryman, A., 2008. *Social Research Methods.* Oxford.

However, these general principles are outlined with two caveats: First, the 'do no harm' principle in scientific research is often combined with a weighing of risks and benefits of the research. The risks posed to the research participants are weighed against the broader benefits to society. This kind of risk-benefit calculus may sit at odds with NGO practice of do no harm, which is underpinned by an NGO's mandate to improve the lives of others. With an NGO's approach to 'do no harm,' posing a risk to a single community on the basis that there may be a wider benefit for other communities may not work as a justifiable approach.

A second caveat is that research ethics frameworks are developed and applied differently across different scientific disciplines in the same country. For example, clinical trials are regulated under different frameworks than social science, and natural science & technology fields can feature their own iterations of the above general principles. Not all scientists will have the same view on research ethics and it will be important for you to arrive at a clear understanding of how a particular scientist or university department approaches its ethical obligations in research. It is, therefore, necessary to **agree upon a common set of established ethical guidelines** prior to visiting the project site so as to ensure the protection of the beneficiaries of science as well as the scientists and NGOs.

Accountability is a particular sub-set within the broader ethical obligations of an NGO or scientific community. With regard to NGOs, accountability mechanisms serve as the main frameworks for ensuring an ethical approach to their interventions[28]. The Humanitarian Accountability Partnership (HAP)[29] standard explicitly covers accountability to both the people that an intervention aims to assist and the local partners involved in that intervention. So requirement 3.2 expects an implementing organisation to:

> *'share with the people its aims to assist and other stakeholders' information appropriate to their need'* and 3.6 expects an organisation to *'work with its partners to agree on how and when they will share information, including with the people they aim to assist, and to put this agreement into practice.'*

However, these mechanisms do not include specific requirements or criteria that dictate what credible science is and how it should be used. This is partly due to the lack of any internationally agreed standard and partly due to the context-specific use of science, which makes it difficult to define standards that would cover every intervention. Some of what NGOs do with the community is innovative, and there is a need for transparency and accountability concerning the source of the scientific information used so that those involved can make the right choice as to whether or not they want to use the information, and be involved in generating the evidence of its benefit to their situation. What is important, as the HAP Standard makes clear, is full accountability and informed consent by all stakeholders and especially from those the intervention intends to assist.

Scientists are held to account by their peers and the process of peer-review. They are also accountable to their institutions and funding bodies but there is little definitive guidance as to how this accountability might be extended to engagement with the humanitarian sector. Accountability needs to be clearly mapped and defined, especially if agencies want to incentivise scientists to engage in humanitarian and development work.

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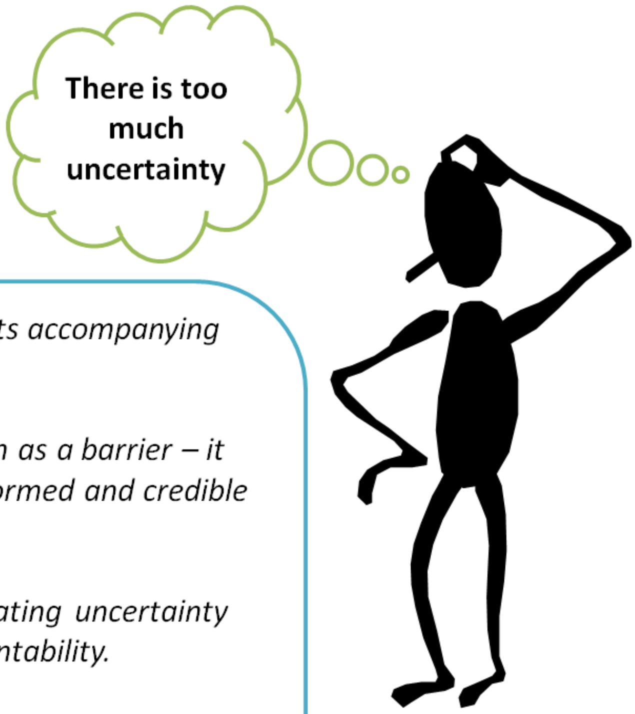
[28] See DEC accountability framework; People in Aid; and Interaction Accountability standards.
[29] Humanitarian Accountability Partnership, 2013. Available online: http://www.hapinternational.org/

The idea of co-production of knowledge by integrating science with local and other sources of knowledge may assist in overcoming any fears scientists may have about being held solely accountable for any decisions based upon the scientific information and knowledge provided. In order to be successful there is, however, a need to remove fear of failure and encourage flexibility in light of new information.




*All scientific information has its accompanying uncertainty.*

*Uncertainty should not be seen as a barrier – it should help to make a more informed and credible decision.*

*Understanding and communicating uncertainty helps to ensure accountability.*

*Often it is difficult to quantify, but where possible, the degree of uncertainty can be measured.*
*Use more than one source or type of information to explore whether these may help to reduce the uncertainty.*

## Section 5: Monitoring and evaluating the impact of science

**Whilst all projects require a process of monitoring and evaluating (M&E) their impact (e.g. a reduction in vulnerability), here we make specific reference to the M&E of integrating science in a project. Monitoring the integration and therefore the impact of science should take place throughout the entire process of engagement since it cannot be assumed that the science makes a valuable contribution or that you will learn and progress from this engagement without first collecting evidence. Monitoring and evaluation (M&E) cannot be reduced to simple formulae; however this section makes *suggestions* on how the impact of integrating science may be measured and how you might adjust your existing techniques**

**Although M&E of science integration is recognised as important it is a relatively new approach for the NGO sector.**

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- *What are you trying to measure?*
- *Do you know when you should be measuring impact?*
- *What indicators are appropriate to the project?*
- *Have you managed to capture the learning as well as the outcomes of the project?*
- *Have you measured the communities' perception of change?*
- *Are there impacts that you can quantify as well as describe?*
- *Have you recorded the unanticipated as well as anticipated impacts?*
- *Have you communicated these impacts beyond your organisation and funder – even if parts of the project were unsuccessful?*

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### *What do we mean by the impact of science?*

To some extent impact is shaped by donors and funders, meaning that both NGOs and scientists are constrained by how their respective funding institutions define and measure impact. Yet partnerships with scientists create dialogues and require flexibility to continuously adapt programmes and projects in light of the learning and knowledge produced as stakeholders work together on a problem. There is, therefore, a need to challenge the funding structures that require predetermined goals and impacts. The best way to influence donors is to demonstrate positive impact through these partnerships, however this requires us to monitor and provide evidence.

Scientists are encouraged to strive towards 'academic excellence', with impact being measured in the context of the number of peer-reviewed articles published in 'high-impact' journals. However, NGOs demonstrate impact through positive change for their target vulnerable communities. Therefore measuring the impact of science information may be new to scientists who may currently only have to demonstrate a *pathway* to impact rather than actual change. Key issues are therefore those common to all impact assessment – the need to **detect** an impact, **attribute** it to the use of scientific information and advice and **triangulate** the impact using more than one assessment methodology or source of information.

In terms of measuring the impact of integrating science, this should encompass not simply the communication of science to users, but also whether:

- the scientific information has been understood;
- the scientific information has been used to guide a decision-making process;
- that decision-making process has resulted in an enhancement of resilience;
- this contributes to achieving the project purpose (or specific objective) and/or any other unexpected purpose;
- the process of integration has been mutually beneficial and accountable to all stakeholders, e.g. scientists, NGOs and communities, resulting in not only learning and change for those using the scientific information but also for those providing it (see case study 6).

This approach is similar to the Kirkpatrick model for training evaluation[30] which has four levels of evaluation: **reaction, learning, behaviour and results**. Importantly, we are not just talking about the evaluation of the outcome of using science but also monitoring and learning from the process of engaging with science.

### *Why do we want to measure the impact of integrating science?*

It is necessary to measure and learn from both successful and failed approaches in integrating science, as it is only through acknowledging those failures that improvements can be made to future projects. Beyond ensuring that the aim of the project and the needs of the community have been addressed, we need to measure impact in order to:

- **inform on-going management** of science integration initiatives, enabling NGO practitioners, scientists and (most importantly) those applying the science to support their resilience to understand the impact of the science they are using and make adjustments accordingly;
- meet **the impact evidence requirements of donors** and influencing their future funding strategies;

[30] Information on the Kirkpatrick model available at http://www.kirkpatrickpartners.com

**Case study 6: Climate Exchange Approach – impact for all stakeholders**

*The information below includes the reflections of the stakeholders included in the climate science exchange outlined in case study 3, which was coordinated by the Humanitarian Futures Programme (HFP). Between 2009-2012 HFP developed a series of two-way exchanges between climate scientists and meteorologists from national meteorological services in Kenya, Senegal and UK and a number of UK universities, communities at risk of flood and drought in Senegal and Kenya and partnering humanitarian and development organisations, with Christian Aid coordinating exchange activities in Kenya (as outlined in case study 3), and the Senegal Red Cross parallel activities in Senegal (Visman 2014).*

*Consisting of a series of community-based workshops and evaluations, tailored systems for provision of seasonal and weekly forecast updates directly to at-risk groups, technical reviews and national workshops timed around the rainy seasons, the exchange has been able to demonstrate benefits for all actors: communities at risk, partnering humanitarian and development agencies and participating scientists:*

***Communities at risk**: Participating groups have increased their trust in and use of forecasts provided by national meteorological services, becoming 'demanding customers' of community-based climate services and also developing for themselves innovative relevant channels for communicating climate information. Participating farmers attributed significant yield improvements to their ability to change key agricultural decisions based on improved access to and understanding of seasonal and short-term forecasts. Communities at risk of flood and drought were able to use information to inform a range of life/livelihood decision making processes, protecting vulnerable members and household assets when heavy rain was forecast, and employing seasonal forecasts and community-managed rain gauges to support planting decisions.*

***Humanitarian and development agencies**: The exchange supported increased access by participating humanitarian and development agencies to climate information providers, resulting in the signing of formal agreements with national meteorological services and on-going engagement in regional climate fora. Exchange between the two country demonstration studies heightened awareness of the potential to employ climate information across timeframes, to support humanitarian, disaster risk reduction and development decision making.*

***Scientists**: The exchange process has been as much about scientists learning how best to contextualise their learning within the realities of those living in complex risk situations, as their developing sufficient understanding amongst directly affected people and policymakers for them to begin to ask the right kind of questions. Creating channels for community concerns to directly inform scientists opens the possibility for re-interrogating existing data to identify new and additional relevance, as well as enabling directly affected people an opportunity to inform the focus of current and on-going scientific research.*

- **grow an evidence base of projects** where science has been integrated successfully (or not) for multiple advocacy objectives:
    - the development of future strategy on what scientific research should focus on;
    - the promotion of public investment for science that is considered useful by vulnerable communities and the organisations providing humanitarian and development services to them;
    - to support advocacy on rights-based issues related to science e.g. preventing the intellectual property rights of vulnerable communities being privatised under corporate copyright laws;
    - to inform strategic planning and promote the uptake of science within NGO as a whole, rather than on an individual project basis;
- **capture learning** from the process of integrating science to inform good practice;
- **ensure accountability** to all stakeholders.

For more information on the challenges of gathering evidence for humanitarian action please refer to the Evidence & Knowledge in Humanitarian Action paper, produced by the Active Learning Network for Accountability and Performance in Humanitarian Action[31].

### *When is impact measured?*

M&E are processes that should be incorporated into any project from the very outset. The impacts of integrating science do not simply relate to the outputs of the project but unexpected outcomes (such as organisational change) can also come about through the engagement with scientists. Projects should be monitored against the aim of integrating science, whilst maintaining a degree of flexibility in the monitoring process to capture any unanticipated changes.

Any impact will take time to emerge, so focusing significant impact assessment in the first year or two of a project is likely to generate slim returns. However mid-term reviews provide an opportunity to identify where impact is emerging and how the evidence gathering process should develop between the mid and end points of an intervention as impact is expected to strengthen. Typically this requires that, and often works best when, evidence gathering is planned and incremental – getting community leaders to maintain simple logs or records ensures that the impact recorded is grounded in community experience and can be used to support community management of scientific advice as well as projects and other stakeholders. This gradual accumulation of results can then be periodically aggregated and assessed so as to ensure that it will meet the anticipated requirement at the end of the project, e.g. from an external evaluation. It also avoids the frantic diversion of staff to intensive impact assessment processes in response to external demands. A key feature of this approach is to measure a smaller number of strongly attributable, priority indicators well and measure them consistently, rather than trying to measure a lot over an unmanageably large sample size.

### *How do we measure the impact of science?*

You may wish to explore how impact can be related to the existing structures and frameworks your organisation adopts. If, for example, we relate impact assessment of science to the Sustainable

[31] Available online: http://www.alnap.org/story/147.aspx

Livelihoods Approach, scientific advice is about enhancing human capital or capacity to make decisions which, in turn enhance the other asset categories (see figure 8). So the focus of impact assessment is how scientific advice has enabled an improvement in effective decision making that delivers a more tangible impact, such as an increase in yield (as in case study 3), an improved flood management system at catchment level or an early warning system that saves lives and assets.

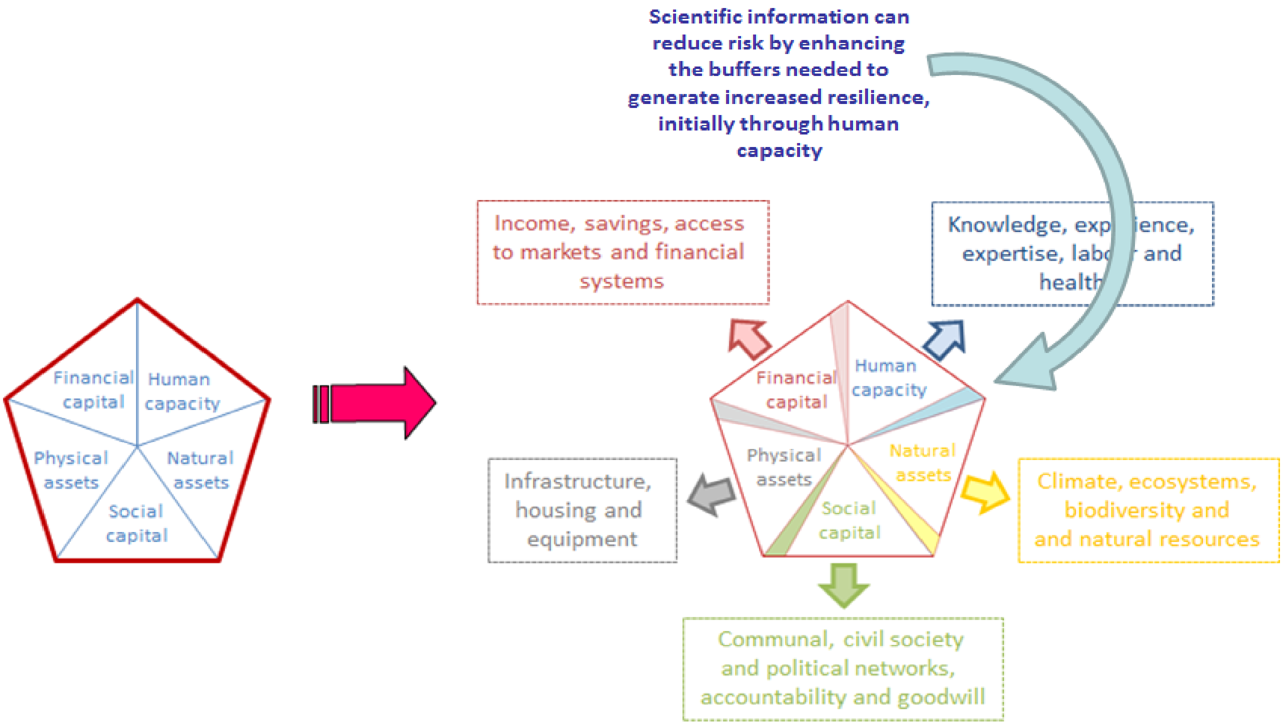


**Figure 8: Relating the integration of scientific information into the sustainable livelihoods approach**. Source: Christian Aid (2013).

The ELRHA *Dialogues for Disaster Anticipation and Resilience*[32] house a number of case studies, with the impact of each of these projects being measured under the following headings:

- Baseline against which impact is measured
- Impact on vulnerability
- Informing specific humanitarian decision making process
- Informing focus of current/proposed scientific research

These case studies are a useful resource in terms of understanding how projects that have integrated science have been measured in terms of the impact of the science.

The challenge is in determining **whether communities have fully internalised the scientific information** (has it been used to inform decision-making and been put into practice) and **how to attribute change (especially in long-term) to the integration of science**.

### *Attributing the impact*

The impact of science can also be viewed as time-dependent; whilst there may be more short-term benefits in terms of knowledge acquired by the community, the long-term impact of integrating

[32] See: http://www.elrha.org/dialogues

science on increasing resilience may only be truly measured when tested by (for example) the occurrence of a stress or shock and whether this results in a major disaster or deterioration of development aims. However, it still may be possible to determine whether things have improved, by looking at the changes that have been made, e.g. in land use planning, the implementation of building codes and the deployment of training.

An example of measuring the impact of science comes from case study 3 and 5. In this case, the emphasis was on following the impact chain as far as was practically possible. So impact at the relatively superficial level could involve simply ascertaining that the climate science being extended to farmer groups was understood, but this raises the question…with what consequences? It should also inform a decision-making process, in this case when to plant, what to plant, etc. But even inquiry to this extent does not draw out the evidence needed to justify the hypothesis that yields will improve, so further investigation attempted to answer this question by asking farmers to what they might attribute the improved production they experienced. Additional resources would have allowed further progress down the chain. So what if yields have increased – does this result in increased income? What has that income been spent on? How has this expenditure improved resilience for the future? Has the experience had any influence on the future generation of climate science and provision of climate services? These are all lines of enquiry to deepen the evidence of the impact of science.

### *Triangulating the impact*

A challenge for impact assessment as we seek to move further down the impact chain is guarding against bias. In the above case, the yield results were based on self-attribution by farmers, which can be prone to a variety of biases. A solution is therefore to triangulate this result with a more quantitative assessment, for example a statistical measurement of yield and comparison with the average yields in the District or comparing with a group that had not used climate science in the same way. This would involve a substantial addition of effort and resources, but will increase the value of the information for both management and advocacy purposes.

Consulting many different sources of information, e.g. from the community, NGO, scientists and other stakeholders involved in the process will help to better determine the extent to which science is responsible for any observable strengthening of resilience. Where possible combining both qualitative and quantitative (e.g. a recorded decrease in the number of floods) measures will also help.

Once impact is measured, it is essential that it is communicated not only to all stakeholders, but to wider audiences in order to inform other agencies and institutions of the benefits (and challenges) of integrating science.

## Summary

The integration of science necessitates the **incorporation of all the relevant, available and credible sources of natural and social scientific information and knowledge deemed essential for solving a humanitarian/development problem and thereby contributing to increased resilience**. The process of science integration should also **help scientists present their results in a relevant and user-friendly context, which should be assisted by those at risk informing and/or being involved in research.**

Science can provide useful information and knowledge but also a series of methods that can help to improve the analysis conducted by NGOs. The process of integrating science is iterative and will require revisiting each of the five components listed below, within a single activity. The users of science should learn from and adjust their approach in light of any new scientific information that emerges during the process of engaging with science and scientists.

1. ***Define the problem and the purpose of integrating science with the users of science***
2. ***Access the science***
3. ***Understand scientific information***
4. ***Apply the science***
5. ***Monitor and evaluate the impact of science***

Finally, science should not be viewed as an added burden but valued as something that can help NGOs and communities make better informed decisions about building resilience.

In order to increase the current level of scientific integration for the purpose of building resilience, we suggest the need for greater funding for interdisciplinary partnerships between NGOs and scientists as well the need to increase scientific capacity within NGOs.

**Acronyms**

| | |
|---|---|
| ABUHC | Aon Benfield UCL Hazard Centre |
| BGS | British Geological Survey |
| CCSMKE | Christian Community Services Mount Kenya East |
| DRR | Disaster Risk Reduction |
| CAFOD | Catholic Agency for Overseas Development |
| ELRHA | Enhancing Learning and Research for Humanitarian Assistance |
| ESRC | Economic and Social Research Council |
| HAP | Humanitarian Accountability Partnership |
| HERR | Humanitarian Emergency Response Review |
| HFP | Humanitarian Futures Programme |
| KMD | Kenya Meteorology Department |
| NERC | Natural Environment Research Council |
| PCM | Project Cycle Management |
| UCL | University College London |
| UKCDS | UK Collaborative on Development Sciences |

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# References

Action Contre la Faim (ACF*). Participatory Risk, Capacity and Vulnerability Analysis. A practitioner manual for field workers.* Available online: http://www.preventionweb.net/files/34 092_34444acf2013practicalmanuelpcva1[1].pdf

Ashdown, 2011. *Humanitarian Emergency Response Review (HERR*). Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/67579/HERR.pdf

Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP), 2013. *Evidence in humanitarian action*. Available online: http://www.alnap.org/story/147.aspx

Bryman, A., 2008. *Social Research Methods*. Oxford.

Conway, G. and Waage, J., 2010. *Science and Innovation for Development*. UK Collaborative on Development Sciences.

Davenport, T. H. and Prusak, L., 1998. *Working Knowledge*. Harvard Business School Press, Boston, Massachusetts.

Disasters Emergency Committee (DEC), 2011. Available online: http://www.dec.org.uk/sites/default/files/files/DEC%20Accountability%20Framework%20-%20Explained.pdf.

Enhancing Learning and Research for Humanitarian Assistance (ELRHA), 2011. *Guide to Constructing Effective Partnerships*. Available online: http://www.elrha.org/uploads/effective-partnerships-report.pdf. [The website includes information on funding opportunities as well as advice on enhancing learning and research for humanitarian assistance. http://www.elrha.org/]

Enhancing Learning and Research for Humanitarian Assistance (ELRHA*). Dialogues for Disaster Anticipation and Resilience*. Available online: http://www.elrha.org/dialogues

Economic and Social Research Council (ESRC), 2012. *Framework for Research Ethics.* Available online: http://www.esrc.ac.uk/about-esrc/information/research-ethics.aspx

Harris, E., 2004. *Building scientific capacity in developing countries,* European Molecular Biology Organization Reports, 5 (**1**), 7-11.

Humanitarian Accountability Partnership, 2013. Available online: http://www.hapinternational.org/

Institute of Development Studies (IDS). *Participatory Methods: Participatory Research and Analysis.* Available online: http://www.participatorymethods.org/task/research-and-analyse

Interaction, 2013. Accountability Standards. Available online: http://www.interaction.org/work/accountability

International Federation of Red Cross and Red Crescent Societies (IFRC), 2005. *World Disaster Report, 2005. Focus on information in disasters.* Available online: http://www.ifrc.org/Global/Publications/disasters/WDR/69001-WDR2005-english-LR.pdf

Levine, S., Ludi, E. and Jones, L., 2011. *Rethinking Support for Adaptive Capacity to Climate Change. The Role of Development Interventions. Findings from Mozambique, Uganda and Ethiopia.* A report for the Africa Climate Change Resilience Alliance. Overseas Development Institute. Available online: http://community.eldis.org/.5a35bbfb/ACCRA%20Rethinking%20Support%20Report%20Final.pdf

National and Environment Research Council (NERC), 2013. NERC Ethics Policy. Available online: http://www.nerc.ac.uk/about/work/policy/ethics/

Science Council, 2013. What is Science? Available online: http://www.sciencecouncil.org/definition

Scheaffer, R. and Young, L., 2010. *Introduction to Probability and its Application*. Brooks and Cole.

Schopfel J. and Farace D.J., Grey literature. In: Bates M.J. and Maack M.N. (eds.) Encyclopedia of Library and Information Sciences. 3rd ed., London England: CRC Press; 2010:2029–2039.

People in Aid, 2013. Available online: http://www.peopleinaid.org/

Turnball, M., Sterret, C. and Hilleboe, A., 2013. *Towards Resilience*. Emergency Capacity Building Project.

Twigg, J., 2007. *Characteristics of a Disaster Resilient Community*.

World Bank, 2012. *Power Analysis.* Available online: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTSOCIALDEVELOPMENT/EXTTOPPSISOU/0,,contentMDK:20590240~isCURL:Y~menuPK:1441813~pagePK:64168445~piPK:64168309~theSitePK:1424003,00.html

Visman, E, 2014. Knowledge is power: Unlocking the potential of science and technology to enhance community resilience through knowledge exchange. *Humanitarian Practice Network Paper*. Number 76. Available online: http://www.odihpn.org/hpn-resources/network-papers

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**Genuine willingness by practitioners to integrate science creates an environment of trust and openness on part of the scientists**

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## References


ActionAid, 1999-2003. Series of internal papers describing the development of vulnerability analysis, spanning 1999-2003.

Agrawal, A. 1995. Dismantling the Divide Between Indigenous and Scientific Knowledge. *Development and Change,* 26**,** 413-439.

Albay Public Safety and Emergency Management Office (APSEMO) 2006a. *Typhoon Milenyo: final damage report.* Internal report.

Albay Public Safety and Emergency Management Office (APSEMO) 2006b. *Typhoon Reming: final damage report.* Internal report.

Albay Public Safety and Emergency Management Office (APSEMO) 2011a. *Summary of Risk Analysis by City/Municipality* (as of January 2011). Internal report.

Albay Public Safety and Emergency Management Office (APSEMO) 2011b. *Summary report: disaster occurrences in the province of Albay.* Internal report.

Albay Public Safety and Emergency Management Office (APSEMO) 2012. *Disaster Occurrences in the Province of Albay 2011.* Summary report. Internal report.

Alexander, D. 2013. Resilience and disaster risk reduction: an etymological journey. *Natural Hazards & Earth System Sciences,* 13.

Allen, P. M. 1988. Dynamic models of evolving systems. *System Dynamics Review,* 4**,** 109-130.

Allenby, B. 2005. Reconstructing Earth: Technology and Environment in the Age of Humans, Washington DC: Island Press.

Anderson, M. B. and Woodrow, P. J., 1998. *Rising from the ashes: development strategies in times of disaster*. ITDG Publishing.

Antes, G. and Clarke, M. 2012. Knowledge as a key resource for health challenges. *The Lancet,* 379**,** 195-196.

Arguden, A. T. and Rodolfo, K. S. 1990. Sedimentologic and dynamic differences between hot and cold laharic debris flows of Mayon Volcano, Philippines. *Geological Society of America Bulletin,* 102**,** 865-876.

Ashdown, L. P. 2011. *Humanitarian Emergency Response Review.* UK Government. [Online] Available: https://www.gov.uk/government/uploads/system/uploads/attachment_
data/file/67579/HERR.pdf [Accessed: 14th June 2014].

Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) 2010*. Incheon Regional Roadmap and Action Plan on DRR through CCA in Asia and the Pacific (Incheon REMAP).* 4th Asian Ministerial Conference on Disaster Risk Reduction: Disaster Risk Reduction through Climate Change Adaptation, 2010 Songdo, Republic of Korea. [Online] Available:

http://www.unisdr.org/files/16210_incheonremap4amcdrrrev1.pdf [Accessed: 11th June 2014].

Aspinall, W. and Cooke, R. M., 1998. Expert judgement and the Montserrat Volcano eruption. *In*: Mosleh, A. and Bari, R. A. (eds.) Proceedings of the 4th International Confreence on Probabilistic Safety Assessment and Management PSAM4, September 13th – 18th 1998, New York City, USA, 3, pp. 2113-2118.

Aspinall, W. P., Auker, M., Hincks, T. K., Mahony, S., Farrokh, N., Pooley, J., Sparks, S. and Syre, E, 2011. GFDRR Volcano Risk Study. Compiled for The World Bank, Washington, D.C.

Bahadur, A. V., Ibrahim, M. and Tanner, T. 2010. The resilience renaissance? Unpacking of resilience for tackling climate change and disasters. *Strengthening Climate Resilience***,** 42.

Bankoff, G. 2003. *Cultures of Disaster: Society and natural hazard in the Philippines,* London: Routledge.

Bankoff, G. and Hilhorst, D., 2009. The politics of risk in the Philippines: Comparing state and NGO perceptions of disaster management. *Disasters,* 33 (**4**), pp. 686-704.

Barriball, K. L. and While, A. 1994. Collecting data using a semi-structured interview: a discussion paper. *Journal of Advanced Nursing,* 19**,** 328-335.

Barrow, O. and Jennings, M. 2001. Introduction. *In:* Barrow, O. and Jennings, M. (eds.) *The Charitable Impulse: NGOs & Development in East & North-East Africa*. Oxford: James Currey Ltd.,2001, pp. 1-27.

Basher, R. 2013. Science and technology for disaster risk reduction: a review of application and coordination needs. Commissioned by the United Nations Office for Disaster Risk Reduction (UNISDR) [Online] Available from: http://www.preventionweb.net/posthfa/documents/Science-and-Technology-for-Disaster-Risk-Reduction.pdf [Accessesd: 13th June 2014].

Bautista, B. C., Bautista, M. L. P., Stein, R. S., Barcelona, E. S., Punongbayan, R., Laguerta, E. P., Rasdas, A. R., Ambubuyog, G. and Amin, E. Q. 1996. Relationship of Regional and Local Structures to Mount Pinatubo Activity. *In:* Newhall, C. and Punongbayan, R. (eds.) *Fire and Mud: Eruptions and Lahars of Mount Pinatubo, Philippines.* Quezon City and Seattle: Philippine Institute of Volcanology and Seismology and University of Washington Press, 1996, pp. 351-369.

Baxter, J. and Eyles, J. 1997. Evaluating qualitative research in social geography: establishing 'rigour' in interview analysis. *Transactions of the Institute of British Geographers,* 22**,** 505-525.

Bazeley, P. 2007. *Qualitative data analysis with NVivo.* London: Sage Publications Ltd.

Benson, C. 2009. Mainstreaming Disaster Risk Reduction into Development: Challenges and Experience in the Philippines. *ProVention Consortium* [Online]. Available from: http://www.preventionweb.net/files/8700_8700mainstreamingphilippines1.pdf [Accessed 8th May 2014].

Benson, C., Myers, M. and Twigg, J. 2001. NGO initiatives in risk reduction: An overview. *Disasters,* 25**,** 199-215.

Benson, C. and Twigg, J. 2004. *Measuring Mitigation: Methodologies for Assessing Natural Hazard Risks and the Net Benefits of Mitigation-a Scoping Study: Synthesis Report*, ProVention Consortium Secretariat. International Federation of Red Cross and Red Crescent Societies.

Benson, C., Twigg, J. and Rossetto, T. 2007. Tools for mainstreaming disaster risk reduction: guidance notes for development organisations. International Federation of Red Cross and Red Crescent Societies and ProVention Consortium. [Online] Available from: http://www.preventionweb.net/files/1066_toolsformainstreamingDRR.pdf [accessed 5th April 2014].

Berti, M., Martina, M. L. V., Franceschini, S., Pignone, S., Simoni, A. and Pizziolo, M. 2012. Probabilistic rainfall thresholds for landslide occurrence using a Bayesian approach. *Journal of Geophysical Research-Earth Surface,* 117, 1-20.

Betts-Symonds, 2003. *Best Practices in Disaster Preperadness: Vulnerability and Capacity Assessment (VCA): Developing a Critical Pathway to Effective Red Cross/Red Crescent Risk/Hazard Assessment/Analysis.* International Federation of the Red Cross and Red Crescent Socities.

Bhaskar, R. 1989. *Reclaiming Reality: A Critical Introduction to Contemporary Philosophy,* London, Verso.

Birkmann, J. 2006. Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions. *In:* Birkmann, J. (ed.) *Measuring vulnerability to natural hazards: towards disaster resilient societies.* Tokyo: United Nations University, 2006, pp. 9-54.

Birkmann, J. and Von Teichman, K. 2010. Integrating disaster risk reduction and climate change adaptation: Key challenges-scales, knowledge, and norms. *Sustainability Science,* 5**,** 171-184.

Boudreau, T. 2009. Solving the risk equation: people-centred disaster risk assessment in Ethiopia. *HPN Network Paper-Humanitarian Practice Network*. London: Overseas Development Institute.

Bovoloa, C. I., Abelea, S. J., Barthursta, J. C., Caballerob, D., Ciglanc, M., Eftichdisd, G., and Simoc, B., 2009. A distributed framework for multi-risk assessment of natural hazards used to model the effects of forest fire on hydrology and sediment yield. *Computers & Geosciences,* 35(**5**), pp. 924-926.

Bowman, L. and White, P. 2012. 'Community' perceptions of a disaster risk reduction intervention at Santa Ana (Ilamatepec) Volcano, El Salvador. *Environmental Hazards,* 11**,** 138-154.

British Red Cross, 2009. *Disaster Risk Reduction Practitioner and Adviser's Workshop.* London: Disaster Preparedness and Risk Reduction Group, December 2009.

Bryman, A. 2008. *Social research methods*. Oxford University press.

Brunetti, M., Peruccacci, S., Rossi, M., Luciani, S., Valigi, D. and Guzzetti, F. 2010. Rainfall thresholds for the possible occurrence of landslides in Italy. *Natural Hazards & Earth System Sciences,* 10, 447-458.

Budimir, M., Duncan, M. and Gill, J., 2013. The Dynamics and Impact of Interacting Natural Hazards – workshop report. [Online] Available: http://www.interactinghazards.com/ [Accessed: 5th August 2014].

Burgess, R. 1984. *In the field: an introduction to field research.* London: Routledge.

Burnard, P., Gill, P., Stewart, K., Treasure, E. and Chadwick, B. 2008. Analysing and presenting qualitative data. *British Dental Journal,* 204**,** 429-432.

Caine, N. 1980. The rainfall intensity-duration control of shallow landslides and debris flows. *Geografiska Annaler Series A,* 62**,** 23-27.

Carney, D., 1998. *Sustainable Rural Livelihoods: What Contribution Can We Make?* London: Department for International Development.

Catane, S. G., Taniguchi, H., Goto, A., Givero, A. P. and Mandanas, A. A. 2005. *Explosive Volcanism in the Philippine.* Sendai: Tōhoku University Press.

Catane, S. G., Abon, C. C., Saturay, R. M., Mendoza, E. P. P. and Futalan, K. M. 2012. Landslide-amplified flash floods-The June 2008 Panay Island flooding, Philippines. *Geomorphology,* 169-170**,** 55-63.

Centre for Epidemiology on the Epidemiology of Disasters (CRED), 2012. *EM-DAT Criteria and Definition.* [Online] Available: http://www.emdat.be/criteria-and-definition [Accessed: 18th June 2014].

Chair's Summary, 2011. Third Session of the Global Platform for Disaster Risk Reduction and World Reconstruction Conference, 2011 Geneva. [Online] Available: http://www.prevention web.net/files/20102_gp2011chairssummary.pdf [Accessed: 14th June 2014].

Chambers, R. 1997. *Whose reality counts? Putting the first last.* London: Intermediate Technology Development Group (ITDG) Publishing.

Charmaz, K. 2006. *Constructing Grounded Theory.* London: Sage.

Checkland, P. 1999. *Systems thinking, systems practice: includes a 30-year retrospective.* Chichester: Wiley.

Chiwaka, E. and Yates, R. 2005. *Participatory Vulnerability Analysis: a step-by-step guide for field staff. ActionAid.* [Online] Available from: http://www.actionaid.org.uk/sites/default/files/doc_lib/108_1_participatory_vulnerability_analysis_guide.pdf [Accessed: 18th February 2014].

Christian Aid and Ewbank, R., 2010. *Integrating climate change adaptation into secure livelihoods. Toolkit 2: developing a climate change analysis*. London: Christian Aid. [Online] Available from: http://www.christianaid.org.uk/Images/Climate-change-adaptation-toolkit-developing-climate-change-analysis-October-2010_tcm15-67268.pdf [Accessed 10th March 2014].

Citizen's Disaster Response Center (CDRC) 2012. *Educators Anchor Disaster Risk Management Programme.* [Online] Available from: http://www.cdrc-phil.com/educators-anchor-disaster-risk-management-program/ [Accessed 21st May 2014].

Coffey, A. and Aitkinson, P. 1996. *Making Sense of Qualitative Data: Complimentary Research Strategies.* Thousand Oaks, California: Sage.

Commission on Climate Change and Development (CCCD), 2009. *Closing the Gaps: Disaster risk reduction and adaptation to climate change in developing countries.* Report of the Commission on Climate Change and Development. Stockholm, Sweded: Edita Sverige AB.

Cooke, B. and Kothari, U. 2001. *Participation: The new tyranny?* London: Zed Books.

Cope, M. 2010. Coding Qualitative Data. *In:* Hay, I. (ed.) *Qualitative Research Methods in Human Geography.* 2nd Edition. Oxford: Oxford University Press, 2010, pp. 281-294.

Corpuz, E., 1985, Chronology of the September-October 1984 eruption of Mayon volcano, Philippines in Punongbayan, R.S. (ed.), 1985, Special issue on the 1984 eruption of Mayon: Philippine Journal of Volcanology, v. 2, p. 36-51 (9 papers, pp.205)

Creswell, J. W. 2014. *Research Design: qualitative, quantitative and mixed methods approaches.* London: SAGE Publications.

Cronin, S., Gaylord, D., Charley, D., Alloway, B., Wallez, S. and Esau, J. 2004. Participatory methods of incorporating scientific with traditional knowledge for volcanic hazard management on Ambae Island, Vanuatu. *Bulletin of Volcanology*, 66, 652-668.

Crozier, M., 1988. The terminology of 'natural hazard' assessment. *New Zealand Journal of Geography,* 86, pp. 5-7.

Cutter, S. L., 2003. The vulnerability of science and the science of vulnerability. *Annals of the Association of American Geographers,* 93(**1**), pp. 1-12.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E. and Webb, J. 2008. A place-based model for understanding community resilience to natural disasters. *Global Environmental Change,* 18**,** 598-606.

Cyranoski, D. 2011. Japan faces up to failure of its earthquake preparations. *Nature,* 471**,** 556-557.

Darnell, A. E. 2009. *The characterisation, communication and mitigation of risks arising from multiple hazards.* ESRC-NERC-DEFRA International Expert Workshop, 7th-8th May 2009. East Anglia, Norwich.

De Dios, H. 2002. *Participatory Capacities and Vulnerabilities Assesement: Finding the Link Between Disasters and Development*. Oxford: Oxfam. [Online] Available from: http://policy-practice.oxfam.org.uk/publications/participatory-capacities-and-vulnerabilities-assessment-finding-the-link-betwee-112522 [Accessed: 25th March 2014].

Delmonaco, G., Margottini, C., and Spizzichino, D., 2006. *ARMONIA methodology for multi-risk assessment and the harmonisation of different natural risk maps. Deliverable 3.1.1. European Commission.* [Online] Available from: http://www.t-6.it/download/Armonia/D.3.1.1_ ARMONIA%20methodology%20for%20multi-risk%20assessment%20and%20the%20harmonization%20of%20different%20natural%20risk%20map.pdf [Accessed 3rd May 2014].

Denzin, N. K. and Lincoln, Y. S. 2000. Introduction: The Discipline and Practice of Qualitative Research. *In:* Denzin, N. K. and Lincoln, Y. S. (eds.) *Handbook of Qualitative Research.* Thousand Oaks: SAGE, 2000, pp. 435-454.

Department for International Development (DFID), 2004. *Disaster risk reduction: a development concern. Policy briefing from output of scoping study*. London: DFID. [Online] Available from: http://www.preventionweb.net/english/professional/publications/v.php?id=1070 [Accessed: 13th May 2014].

Department for International Development (DFID), 2011. *Defining Disaster Resilience: A DFID Approach Paper.* London: DFID. [Online] Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/186874/defining-disaster-resilience-approach-paper.pdf [Accessed: 13th May 2014].

Department for International Development (DFID), 2012. *Multi-hazard disaster risk assessment.* London: DFID. [Online] Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/204933/Multi-hazard_risk_assessment_guidance.pdf [Accessed: 13th May 2014].

De Pippo, T., Donadio, C., Pennetta, M., Petrosino, C., Terlizzi, F. and Valente, A. 2008. Coastal hazard assessment and mapping in Northern Campania, Italy. *Geomorphology,* 97**,** 451-466.

Dilley, M. 2006. Setting priorities: global patterns of disaster risk. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences,* 364**,** 2217.

Dilley, M., Chen, R. S., Deichmann, U., Lerner-Lam, A., Arnold, M., Agwe, J., Buys, P., Kjekstad, O., Lyon, B. and Yetman, G. 2005. *Natural disaster hotspots: A global risk analysis*. [Online} Available from: http://econ.worldbank.org/external/default/main?pagePK=64165259&piPK=64165421&theSitePK=469372&menuPK=64216926&entityID=000160016_20051123111032 [Accessed: 11th January 2014].

Donovan, K., Sidaway, J. D. and Stewart, I. 2011. Bridging the geo-divide: Reflections on an interdisciplinary (ESRC/NERC) studentship. *Transactions of the Institute of British Geographers,* 36**,** 9-14.

Dowling, R. 2010. Power, Subjectivity, and Ethics in Qualitative Research. *In:* Hay, I. (ed.) *Qualitative Research Methods in Human Geography.* Third Edition. Oxford: Oxford University Press, 2010, pp.26-39.

Duncan, M., Crowley, K., Cornforth, R., Edwards, S., Ewbank, R., Karbassi, P., McLaren, C., Penya, J. L., Obrecht, A., Sargeant, S. and Visman, E. 2014. *Integrating science into humanitarian and development planning and practice to enhance community resilience: guidelines for NGO practitioners.* [Online] Available from: http://www.ukcds.org.uk/resources/integrating-science-into-humanitarian-and-development-planning [Accessed: 15th June 2014].

Dunn, K. 2010. Interviewing. *In:* Hay, I. (ed.) *Qualitative Research Methods in Human Geography.* 2nd Edition. Oxford: Oxford University Press, 2010, pp. 101-138.

Enhancing Learning and Relationships for Humanitarian Assistance (ELRHA), 2012. *Guide to Constructing Effective Partnerships*. [Online] Available from: http://www.elrha.org/effective-partnerships-guide [Accessed: 1th June 2014].

Evans, S. G., Guthrie, R. H., Roberts, N. J. and Bishop, N. F. 2007. The disastrous 17 February 2006 rockslide-debris avalanche on Leyte Island, Philippines: A catastrophic landslide in tropical mountain terrain. *Natural Hazards and Earth System Science*, 7, 89-101.

Fano, J. A., Alpasan, M. T., Mitsunaga, T. and Tokunaga, Y. *2007. The Mayon 2006 Debris Flows: The Destructive Path of Typhoon Reming.* FCSEC Technical Report Volume 3 Department of Public Works and Highways. Pasig City, Metro Manila, Philippines.

Feinstein International Center (FIC) 2010. *Humanitarian Horizons: A Practitioner's Guide to the Future. Medford, Massachusetts.* [Online] Available from: http://euprha.org/upload/2014/06/HFP-Humanitarian-Horizons-Jan-2010.pdf [Accessed: 14th May 2014].

Fischer, F. 2000. *Citizens, experts, and the environment: The politics of local knowledge*. Durham and London, USA: Duke University Press.

Flyvbjerg, B. 2006. Five misunderstandings about case-study research. *Qualitative inquiry,* 12**,** 219-245.

Foster, H. D. 1980. *Disaster planning; the preservation of life and property.* New York: Springer-Velag.

Gaillard, J. C. 2010. Vulnerability, capacity and resilience: Perspectives for climate and development policy. *Journal of International Development,* 22**,** 218-232.

Gallopin, G., 2006. Linkages between vulnerability, resilience, and adaptive capacity *Global Environmental Change,* 16, 293–303.

Garcin, M., Desprats, J. F., Fontaine, M., Pedreros, R., Attanayake, N., Fernando, S., Siriwardana, C. H. E. R., De Silva, U. and Poisson, B. 2008. Integrated approach for coastal hazards and risks in Sri Lanka. *Natural Hazards and Earth System Science,* 8**,** 577-586.

Giardini, D. and Bashman, P., 1993. Global Seismic Hazard Assessment Program (GSHAP). *Annali di Geofisica* XXXVI(3-4), pp. 3-13. [Online] available from: http://www.annalsofgeophysics.eu/index.php/annals/article/viewFile/4256/4325 [Accessed 14th June 2014].

Gibbs, G. R. 2007. Analyzing qualitative data. *In:* Flick, U. (ed.) *The Sage Qualitative Research Kit.* Thousand Oaks, California: Sage, 2007.

Global Facility for Disaster reduction and Recovery (GFDRR), 2010. *Philippines*. [Online] Available from: http://gfdrr.org/ctrydrmnotes/Philippines.pdf [Accessed: 11th June 2014].

Gorman, M. E. 2005. Earth systems engineering management: Human behaviour, technology and sustainability. *Resources, Conservation and Recycling*, 44, 201-213.

Government Office for Science (GOS). 2012. *The Use of Science in Humanitarian Emergencies and Disasters. UK.* [Online] Available: https://www.gov.uk/government/uploads/system /uploads/attachment_data/file/278694/12-848-use-of-science-in-humanitarian-emergencies-disasters.pdf [Accessed: 22nd June 2014].

Green, D. 2013. *Why are NGOs and Academics collaborating more?* [Online] Available from: http://oxfamblogs.org/fp2p/why-are-ngos-and-academics-collaborating-more/ [Accessed: 15th June 2014].

Greiving, S., Fleischhauer, M. and Lückenkötter, J. 2006. A methodology for an integrated risk assessment of spatially relevant hazards. *Journal of Environmental Planning and Management,* 49**,** 1-19.

Guest, G., Namey, E. E. and Mitchell, M. L. 2013. *Collecting Qualitative Data: A Field Manual for Applied Research.* London: SAGE.

Guha-Sapir, D., Vos, F., Below, R. and Ponserre, S. 2011. Annual Disaster Statistical Review 2010. Brussels, Belgium.

Gunderson, L. H. and Holling, C. S. 2002. *Panarchy: understanding transformations in human and natural systems*. Washington DC: Island Press.

Guthrie, R. H., Evans, S. G., Catane, S. G., Zarco, M. a. H. and Saturay Jr, R. M. 2009. The 17 February 2006 rock slide-debris avalanche at Guinsaugon Philippines: A synthesis. *Bulletin of Engineering Geology and the Environment,* 68**,** 201-213.

Guzzetti, F., Peruccacci, S., Rossi, M. and Stark, C. 2008. The rainfall intensity–duration control of shallow landslides and debris flows: an update. *Landslides,* 5**,** 3-17.

Hammersley, A. 1992. *What's Wrong with Ethnography.* London: Routledge.

Hammersley, M. and Gomm, R. 2000. Introduction. *In:* Gomm, R., Hammersley, M. and Foster, P. (eds.) *Case Study Method: Key Issues, Key Texts.* London: SAGE, 2000, pp 1-16.

Han, J., Wu, S. and Wang, H. 2007. Preliminary Study on Geological Hazard Chains. *Earth Science Frontiers,* 14**,** 11-20.

Harris, K. and Bahadur, A., 2011. *Harnessing synergies: mainstreaming climate change adaptation in disaster risk reduction programmes and policies.* [Online] Insitute of Development Studies and ActionAid. Available from: http://www.ids.ac.uk/idspublication/ harnessing-synergies-mainstreaming-climate-change-adaptation-in-disaster-risk-reduction-programmes-and-policies [Accessed 6th June 2014].

Hay, I. 2010. *Qualitative research methods in human geography,* Oxford, Oxford University Press.

Hayes, G. P., Briggs, R. W., Sladen, A., Fielding, E. J., Prentice, C., Hudnut, K., Mann, P., Taylor, F. W., Crone, A. J., Gold, R., Ito, T. and Simons, M. 2010. Complex rupture during the 12 January 2010 Haiti earthquake. *Nature Geoscience,* 3**,** 800-805.

Haynes, K., Barclay, J. and Pidgeon, N. 2007. Volcanic hazard communication using maps: An evaluation of their effectiveness. *Bulletin of Volcanology,* 70**,** 123-138.

Heijmans, A. and Victoria, L. P. 2001. Citizenry-Based & Development-Oriented Disaster Response, Metro Manila.

Hilhorst, D. 2003. *The real world of NGOs: Discourses, diversity and development*. London: Zed Books Ltd.

Hill, L. J., Sparks, R. S. J. and Rougier, J. C. 2013. Risk assessment and uncertainty in natural hazards. *In:* Rougier, J., Sparks, S. and Hill, L. (eds.) *Risk and Uncertainty Assessment for Natural Hazards.* Cambridge: Cambridge University Press, 2013, pp. 1-18.

Hincks, T. K., Aspinall, W. P., Sparks, R. S. J., Holcombe, E. A. and Kern, M. 2013. Landslide and avalanche hazards. *In:* Rougier, J., Sparks, S. and Hill, L. (eds.) *Risk and Uncertainty Assessment for Natural Hazards.* Cambridge: Cambridge University Press, 2013, pp. 275-316.

Hjorth, P. and Bagheri, A. 2006. Navigating towards sustainable development: A system dynamics approach. *Futures,* 38**,** 74-92.

Humanitarian Accountability Partnership (HAP), 2010. *The 2010 HAP Standard in Accountability and Quality Management.* [Online] Available from: http://www.hapinternational.org/pool/files/2010-hap-standard-in-accountability.pdf [Accessed: 30th September 2014].

Innocenti, D. and Albrito, P. 2011. Reducing the risks posed by natural hazards and climate change: The need for a participatory dialogue between the scientific community and policy makers. *Environmental Science and Policy,* 14**,** 730-733.

International Council for Science (ICSU), 2008. *A Science Plan for Integrated Research on Disaster Risk: Addressing the challenge of natural and human-induced environmental hazards*. [Online] Available: http://www.icsu.org/publications/reports-and-reviews/IRDR-science-plan/irdr- science-plan.pdf [Accessed: 9th May 2015].

International Federation of the Red Cross, 1993: *World Disaster Report 1993*.

International Federation of Red Cross and Red Crescent Societies (IFRC/RC), 2003. The Code of Conduct for the International Red Cross and Red Crescent Movement and NGOs in Disaster Relief. [Online] Available: http://www.ifrc.org/Docs/idrl/I259EN.pdf [Accessed: 30th July 2014].

International Federation of Red Cross and Red Crescent Societies (IFRC/RC), 2007. *How to do a VCA: a practical step-by-step guide for Red Cross Red Crescent staff and volunteers.* [Online] Available from: http://www.ifrc.org/Global/Publications/disasters/vca/how-to-do-vca-en.pdf [ Accessed: 20th May 2014].

Interagency Resilience Working Group, 2012. *The Characteristics of Resilience Building: a discussion paper.* [Online] Available from: http://community.eldis.org/?233@@.5ad4406d!enclosure=.5ad4406e&ad=1 [Accessed: 22nd June 2014].

Irwin, A. 1995. *Citizen Science: A Study of People, Expertise and Sustainable Development.* London: Routledge.

Irwin, A., Dale, A. and Smith, D. 1996. Science and Hell's kitchen: the local understanding of hazard issues. *In:* Irwin, A. and Wynne, B. (eds.) *Misunderstanding of Science? The Public Reconstruction of Science and Technology.* Cambridge: Cambridge University Press, 1996, pp. 47-64.

Irwin, A. and Michael, M. 2003. *Science, Social Theory & Public Knowledge*. Maidenhead: Open University Press.

Islamic Relief UK, 2010. *Flooded and forgotten: the ongoing crisis threatening lives and livelihoods in Pakistan.* [Online] available from: http://www.curtisresearch.org/FINAL.001_ Flooded_and_Forgotten.pdf [Accessed 3rd May 2012].

Iverson, R. M., Schilling, S. P. and Vallance, J. W. 1998. Objective delineation of lahar-inundation hazard zones. *Geological Society of America Bulletin,* 110**,** 972-984.

Jakob, M. 2005. Debris-flow hazard analysis. *Debris-flow hazards and related phenomena. In*: Jakob, M. and Hungr, O.(ed.) *Debris-flow hazards and related phenomena.* Chichester: Springer- Praxis, 2005, pp. 411-443.

Jan, C.-D. and Chen, C.-L. 2005. Debris flows caused by Typhoon Herb in Taiwan. *In*: Jakob, M. and Hungr, O.(ed.) *Debris-flow hazards and related phenomena.* Chichester: Springer- Praxis, 2005, pp. 539-564.

Johnston, D. M., Lai, M. S. B. C.-D., Houghton, B. F. and Paton, D. 1999. Volcanic hazard perceptions: comparative shifts in knowledge and risk. *Disaster Prevention and Management,* 8**,** 118-126.

Kappes, M. S., Keiler, M. and Glade, T. 2010. From Single- to Multi-Hazard Risk Analyses: a concept addressing emerging challenges. *In:* Malet, J.-P., Glade, T. and Casagli, N. (eds.) Mountain Risks International Conference: Bringing Science to Society, Firenze, Italy, November 2010. CERG Editions, Strasbourg: France, 2010, pp. 24-26.

Kappes, M. S., Papathoma-Köhle, M. and Keiler, M. 2011. Assessing physical vulnerability for multi-hazards using an indicator-based methodology. *Applied Geography,* 32**,** 577-590.

Kappes, M., Keiler, M., Elverfeldt, K. and Glade, T. 2012. Challenges of analyzing multi-hazard risk: a review. *Natural Hazards*, 64, 1925-1958.

Kearns, R. 2010. Seeing with Clarity: Understanding Observational Research. *In:* Hay, I. (ed.) *Qualitative Research Methods in Human Geography.* Third Edition. Oxford: Oxford University Press, 2010, pp. 241-258.

Lacasse, S., Eidsvig, U., Nadim, F., Høeg, K. and Blikra, L. H. 2008. Event Tree analysis of Åknes rock slide hazard. 2008. 551-557. *In: Locat, J., Perret, D., Turmel, D., Demers, D. and Leroueil, S.* Comptes rendus de la 4e Conférence canadienne sur les géorisques: des causes à la gestion. Proceedings of the 4th Canadian Conference on Geohazards: From Causes to Management. Presse de l'Université Laval, Québec.

Landström, C., Whatmore, S. J., Lane, S. N., Odoni, N. A., Ward, N. and Bradley, S. 2011. Coproducing flood risk knowledge: redistributing expertise in critical 'participatory modelling'. *Environment and Planning A,* 43**,** 1617-1633.

Lavigne, F., Thouret, J. C., Voight, B., Suwa, H. and Sumaryono, A. 2000. Lahars at Merapi volcano, Central Java: An overview. *Journal of Volcanology and Geothermal Research,* 100**,** 423-456.

Lecompte, M. D. and Goetz, J. P. 1982. Problems of reliability and validity in ethnographic research. *Review of educational research,* 52**,** 31-60.
Lee, E. M. and Jones, D. K. 2004. *Landslide risk assessment*. London: Thomas Telford.

Lincoln, Y. S. and Guba, E. 1985. Naturalistic Inquiry. California, USA: SAGE.

Louw, K., Rosen, T., Schulman, M., Vaverka, C. and Wolf, S., 2011. A Summary Report o f the Third Session of the Global Platform for Disaster Risk Reduction. *Global Platform f or Disaster Risk Reduction Bulletin.* [Online] IISD Reporting Services. Available from: http ://www.iisd.ca/download/pdf/sd/ymbvol141num3e.pdf [last accessed 3rd May 2014].

McIlwaine, C., 2006. Using Indigenous and Local Knowledge and Literature. *In:* Desai, V. and Potter, R. B. (eds.) *Doing Development Research.* London: SAGE Publications, 2006, pp.222-231.

Manila Observatory and University of the Philippines National Institute for Geological Sciences (MO-UPNIGS) 2009. *RS-GIS-based Risk Mapping of Climate and Geophysical Hazards in Albay: A Post-Reming Scenario.* Quezon City, Manila: Manila Observatory.

Manyena, B. S., O'Brien, G., O'Keefe, P. and Rose, J. 2011. Disaster resilience: A bounce back or bounce forward ability? *Local Environment,* 16**,** 417-424.

Martí, J., Aspinall, W. P., Sobradelo, R., Felpeto, A., Geyer, A., Ortiz, R., Baxter, P., Cole, P., Pacheco, J., Blanco, M. J. and Lopez, C. 2008. A long-term volcanic hazard event tree for Teide-Pico Viejo stratovolcanoes (Tenerife, Canary Islands). *Journal of Volcanology and Geothermal Research,* 178**,** 543-552.

Marzocchi, W., Garcia-Aristizabal, A., Gasparini, P., Mastellone, M. L. and Ruocco, A. D. 2012a. Basic principles of multi-risk assessment: A case study in Italy. *Natural Hazards,* 62**,** 551-573.

Marzocchi, W., Mastellone, M., Di Ruocco, A., Novelli, P., Romeo, E. and Gasparini, P. 2009. Principles of multi-risk assessment. *Interaction Amongst Natural and Man-induced Risks. European Commission*.

Marzocchi, W., Newhall, C. and Woo, G 2012b. The scientific management of volcanic crises. *Journal of Volcanology and Geothermal Research,* 247-248, 181-189.

Marzocchi, W., Sandri, L., Gasparini, P., Newhall, C. and Boschi, E. 2004. Quantifying probabilities of volcanic events: The example of volcanic hazard at Mount Vesuvius. *Journal of Geophysical Research B: Solid Earth,* 109**,** 1-18.

Manyena, S. B., O'Brien, G., O'Keefe, P., Rose, J. 2011. Disaster resilience: a bounce back or bounce forward ability? *Local Environment*, 16(5): 417-424.

Matus, C. L. 2013. *For Boholanos: After super quake, a super typhoon*. Inquirer Visayas. [Online] Available from: http://newsinfo.inquirer.net/524245/for-boholanos-after-super-quake-a-super-typhoon [Accessed 11th June 2014].

Maynoux, L. 2006. Quantitative, Qualitative or Participatory? Which Method, for What and When? *In:* Desai, V. and Potter, R. B. (eds.) *Doing Development Research.* London: SAGE, 2006, pp. 115-129.

McBean, G. and Ajibade, I., 2009. Climate change, related hazards and human settlements. *Current Opinion in Environmental Sustainability,* 1(**2**), pp.179-186.

McCall, M. K. and Peters-Guarin, G. 2012. Participatory action research and disaster risk. *In:* Wisner, B., Gaillard, J. and Kelman, I. (eds.) *Handbook of hazards and disaster risk reduction.* Abingdon: Routledge, 2012 pp. 772-786.

McCloskey, J., Nalbant, S. S. and Steacy, S., 2005. Indonesian earthquake: Earthquake risk from co-seismic stress. *Nature,* 434(**7031**), pp.291-291.

McCracken, G. 1988. *The long interview*. London: SAGE.

Martí, J., Aspinall, W. P., Sobradelo, R., Felpeto, A., Geyer, A., Ortiz, R., Baxter, P., Cole, P., Pacheco, J., Blanco, M. J. and Lopez, C. 2008. A long-term volcanic hazard event tree for Teide-Pico Viejo stratovolcanoes (Tenerife, Canary Islands). *Journal of Volcanology and Geothermal Research*, 178, 543-552.

Mercer, C. 2002. NGOs, civil society and demoncratization: a critical review of the literature. *Progress in Development Studies,* 2**,** 5-22.

Mercer, C. 2006. Working with partners: NGOs and CBOs. *In:* Desai, V. and Potter, R. B. (eds.) *Doing Development Research.* London: SAGE, 2006, pp. 94-103.

Mercer, J. 2010. Disaster risk reduction or climate change adaptation: Are we reinventing the wheel? *Journal of International Development,* 22**,** 247-264.

Mercer, J. 2012. Knowledge and disaster risk reduction. *In:* Wisner, B., Gaillard, J. and Kelman, I. (eds.) *Handbook of hazards and disaster risk reduction.* Routledge, Abingdon, pp. 96-108.

Mercer, J., Kelman, I., Lloyd, K. and Suchet-Pearson, S. 2008. Reflections on use of participatory research for disaster risk reduction. Area, 40, 172-183.

Mercer, J., Kelman, I., Suchet Pearson, S. and Lloyd, K. 2009. Integrating indigenous and scientific knowledge bases for disaster risk reduction in Papua New Guinea. *Geografiska Annaler: Series B, Human Geography,* 91**,** 157-183.

Mercer, J., Kelman, I., Taranis, L. and Suchet-Pearson, S. 2010. Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters,* 34**,** 214-239.

Mitchell, T. 2006. *Building a Disaster Resilient Future: Lessons from Participatory Research in St. Kitts and Montserrat.* PhD thesis, University College London.

Mitchell, T. and Harris, K. 2012. *Resilience: A risk management approach*. Background Note, January 2012. London: Overseas Development Institute. [Online] Available from: http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/7552.pdf [Accessed: 3rd May 2014].

Mitchell, T. and Van Aalst, M. 2008. *Convergence of Disaster Risk Reduction and Climate Change Adaptation. A review for DFID*. Brighton: IDS. [Online] Available from: http://www.preventionweb.net/files/7853_ConvergenceofDRRandCCA1.pdf [Accessed: 10th June 2014].

Mitchell, T., Van Aalst, M. and Villanueva, P. S. 2010b. Assessing Progress on Integrating Disaster Risk Reduction and Climate Change Adaptation in Development Process. *Strengthening Climate Resilience Discussion Paper 2.*

Mitchell, T., Ibrahim, M., Harris, K., Hedger, M., Polack, E., Ahmed, A., Hall, N., Hawrylyshyn, K., Nightgale, K., Onyango, M., Adow, M. and Mohammed, S., 2010a. *Climate Smart Disaster Risk Management.* Strengthening Climate Resilience. Brighton: IDS. [Online] Available from: http://www.ids.ac.uk/idspublication/climate-smart-disaster-risk-managment [Accessed 3rd May 2012].

Mosquera-Machado, S. and Dilley, M., 2009. A comparison of selected global disaster risk assessment results. *Natural Hazards,* 48(3), pp.439-456.

Muñoz-Salinas, E., Castillo-Rodríguez, M., Manea, V., Manea, M. and Palacios, D. 2009. Lahar flow simulations using LAHARZ program: Application for the Popocatépetl volcano, Mexico. *Journal of Volcanology and Geothermal Research,* 182**,** 13-22.

National Aeronautics and Space Administration (NASA). 2006. *Hurricane Season 2006: Durian (Western Pacific): Typhoon Durian triggers massive mudslides in the Philippines* [Online]. Available from: http://www.nasa.gov/mission_pages/hurricanes/archives/2006/h2006_durian.html [Accessed 22nd May 2014].

National Disaster Coordinating Council (NDCC), 2006. *NDCC Media Update re Typhoon "Reming" (Durian)* [Online] Available from: http://reliefweb.int/sites/reliefweb.int/files/resources/1A0352880F3E347B4925723E0022D0CF-Full_report.pdf [Accessed 21st April 2014].

National Statistics Office, 2014. Philippines in Figures [Online]. Available from: http://www.census.gov.ph/ [Accessed 10th June 2014].

Neri, A., Aspinall, W. P., Cioni, R., Bertagnini, A., Baxter, P. J., Zuccaro, G., Andronico, D., Barsotti, S., Cole, P. D., Esposti Ongaro, T., Hincks, T. K., Macedonio, G., Papale, P., Rosi, M., Santacroce, R. and Woo, G. 2008. Developing an Event Tree for probabilistic hazard and risk assessment at Vesuvius. *Journal of Volcanology and Geothermal Research,* 178**,** 397-415.

Neri, M., Le Cozannet, G., Thierry, P., Bignami, C. and Ruch, J. 2013. A method for multi-hazard mapping in poorly known volcanic areas: An example from Kanlaon (Philippines). *Natural Hazards and Earth System Sciences,* 13**,** 1929-1943.

Newhall, C. and Hoblitt, R. 2002. Constructing event trees for volcanic crises. *Bulletin of Volcanology,* 64**,** 3-20.

Newhall, C. G. and Self, S. 1982. The volcanic explosivity index (VEI) an estimate of explosive magnitude for historical volcanism. *Journal of Geophysical Research: Oceans,* 87**,** 1231-1238.

Newing, H. 2011. *Conducting research in conservation: social science methods and practice*, Routledge.

Nicolas, G., Schwartz, B. and Pierre, E. 2009. *Weathering the storm like Bamboo: the Strength of Haitians in Coping with Natural Disasters. In:* Kalayjian, A., Eugene, D. and Reyes, G. (eds.)

*International handbook of emotional healing: ritual and practices for resilience after mass trauma.* Westport, CT: Greenwood Publishing Group, Inc.
Normile, D. 2011. Scientific consensus on great quake came too late. *Science,* 332**,** 22.

Office of Civil Defense (OCD) 2006. *Summary of Data for Typhoon Reming and Milenyo*. Internal report. OCD Philippines.

Okkerman, J., Geronimo, S., Umbal, J. and Palad, N. 1985. Study into the mechanisms of debris flow during/after the 1984 eruption of Mayon volcano. *Philippine Journal of Volcanology,* 2**,** 94-142.

Olhoff, A. and Schaer, C., 2010. Screening tools and guidelines to support the mainstreaming of climate change adaptation into development assistance: A stocktaking report. Environment and Energy, United Nations Development Programme. [Online] available from: http://www.preventionweb.net/files/13122_UNDPStocktakingReportCCmainstreamin.pdf [Accessed: 3rd May 2012].

Orense, R. P. and Ikeda, M. 2007. Damage caused by typhoon-induced lahar flows from Mayon Volcano, Philippines. *Soils and Foundations,* 47**,** 1123-1132.

Paguican, E. M. R., Lagmay, A. M. F., Rodolfo, K., Rodolfo, R., Tengonciang, A. M. P., Lapus, M., Baliatan, E. and Obille, E. 2009. Extreme rainfall-induced lahars and dike breaching, 30 November 2006, Mayon Volcano, Philippines. *Bulletin of Volcanology,* 71**,** 845-857.

Peduzzi, P., Dao, H., Herold, C. and Mouton, F., 2009. Assessing global exposure and vulnerability towards natural hazards: the Disaster Risk Index. *Natural Hazards and Earth Systems Science,* 9(**4**), pp.1149-1159.

Pelling, M. 2011. *Adaptation to Climate Change: From resilience to transformation*. London: Routledge.

Peters-Guarin, G., Mccall, M. K. and Van Westen, C. 2012. Coping strategies and risk manageability: Using participatory geographical information systems to represent local knowledge. *Disasters*, 36, 1-27.

Pielke, R. A. 2007. *The honest broker: making sense of science in policy and politics*. Cambridge: Cambridge University Press.

Phil GIS, 2013. *Philippine GIS Data Online Clearing House*. [Online] Available: http://philgis.org/ [Accessed: 18th June 2014].

Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA) 2006. *Philippines: Severe weather bulletin #5 - Tropical cyclone warning/Typhoon "Reming" (Durian)* [Online]. Available from: http://reliefweb.int/report/philippines/philippines-severe-weather-bulletin-5-tropical-cyclone-warningtyphoon-reming [Accessed 25th May 2014].

Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA) 2007. Typhoon “Reming” (Durian). A STRIDE Team Report. November 28 - December 03, 2006. PAGASA internal report.

Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA) 2012. *Rainfall data January 1978 - August 2012.*

Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA), 2013. *Storm warning signal.* [Online] Available: http://www.pagasa.dost.gov.ph/learning-tools/public-storm-warning-signal [Accessed: 14th June 2014].

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2000. *Mayon Volcano Lahar Hazards Map as of January 2000.* [Online] Available: http://www.phivolcs.dost.gov.ph/ [Accessed: 11th June 2014]

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2001. *Mayon Volcano Alert Levels* [Online]. Available from: http://www.phivolcs.dost.gov.ph/html/update_VMEPD/vmepd/vmepd/mayonAlert.htm [Accessed 21st May 2014].

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2006a. *Lahar and Flood Hazards Mapping and Assessment after Super Typhoon Reming and Typhoon Seniang.* Internal report.

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2006b. *QRT investigation of the effects of Typhoon Reming in the vicinity of Mayon Volcano December 1-2, 2006.* Internal report.

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2007a. *Mayon Volcano after Supertyphoon Reming: Fieldwork Guide.* Internal report.

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2007b. *Report of Partial Survey Results on Typhoon Reming-Impacted Channels of Mayon Volcano, April and July 2007.* Internal report.

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2008a. *List of active volcanoes.* [Online] Available: http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=57:active-volcanoes&catid=55&Itemid=114 [Accessed 18th June 2014].

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2008b. *Annual Report 2007.* Quezon City, Manila: PHIVOLCS.

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2011a. *Investigation of the Impacts of Tropical Storm Juaning on Mayon Volcano and Albay Province.* Quick Response Tem (QRT) Field Visit Report. 26 July to 1 August 2011. Internal report.

Philippine Institute of Volcanology and Seismology (PHIVOLCS) 2011b. *Revised Mayon Volcano Lahar Hazard Map.*

Philippine Institute of Volcanology and Seismology (PHIVOLCS), 2011b. *PHIVOLCS eruption data updated from Ramos-Villarta et al., 1985; Newhall, 1977; Bornas et al., 2009; Arpa et al., 2006; Delos Reyes, 2003. In*: Volcano History and Recent Activity Mayon Volcano, Philippines. Field Course on Philippine GeoHazards_PHIVOLCS-UPNIGS-University of Hamburg–03.07.2011. Internal presentation.

Prabhakar, S. V. R. K., Srinivasan, A. and Shaw, R., 2009. Climate change and local level disaster risk reduction planning: Need, opportunities and challenges. *Mitigation and Adaptation Strategies for Global Change,* 14(**1**), pp.7-33.

PreventionWeb, 2012. *Global Platform for Disaster Risk Reduction*. [Online] Available from: http://www.nweb.net/english/hyogo/GP/ [Accessed 3rd May 2012].

Global Volcanism Programme (GVP), 2013. *Mayon*. Smithsonian Institute [Online] Available from: http://www.volcano.si.edu/volcano.cfm?vn=273030 [Accessed: 13th May 2012].

Provincial Government of Albay and Center for Initiatives and Research for Climate Adaptation (CIRCA) 2010. *Province of Albay, Philippines: responding to the challenge of disaster risk reduction and climate change adaptation*. Strengthening Climate Resilience Programme [Online] http://www.preventionweb.net/files/section/230_Philippinesalbaycasestudy.pdf [Accessed 21st May 2014].

Punongbayan, R. S. 1985. An approach for estimating ages of active volcanoes. *Philippine Journal of Volcanology,* 2**,** 191-205.

Ramos-Villarta, S. C., Corpuz, E. G. and Newhall, C. G. 1985. Eruptive history of Mayon volcano, Philippines. *Philippine Journal of Volcanology,* 2**,** 36.

Rees, J., Loughlin, S., Tappin, D., England, P., Petley, D., Barclay, J. And McCloskey, J. 2012. Anticipation of Geophysical Hazards. UK Government of Science. [Online] Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/286641/12-1301-anticipation-of-geophysical-hazards.pdf [Accessed: 11th June 2014].

Ritchey, T., 2006. Modeling Multi-Hazard Disaster Reduction Strategies with Computer-Aided Morphological Analysis. *In*: Van de Walle, B. and Turoff, M. (eds.) Proceedings of the 3rd International ISCRAM Conference, Newark, NJ (USA), May 2006, pp. 1-8.

Rivera, W. M., Qamar, M. K., and Crowder, L. V., 2001. Food and Agriculture Association Agric ultural and Rural Extension Worldwide Options for Institutional Reform in the Developin Count ries. Food and Agriculture Organization of the United Nations, Rome. [Online] Rome FAO. Available from: ftp://ftp.fao.org/docrep/fao/004/y2709e/y2709e.pdf [Accessed 3rd May 2014].

Robinson, O. C. 2014. Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide. *Qualitative Research in Psychology,* 11**,** 25-41.

Rodolfo, K. S. 1986. Mabinit lahar channel, Mayon Volcano. *Philippine Journal of Volcanology,* 3**,** 73-89.

Rodolfo, K. S. 1989. Origin and early evolution of lahar channel at Mabinit, Mayon Volcano, Philippines. *Geological Society of America Bulletin,* 101**,** 414-426.

Rodolfo, K. S. 1995. *Pinatubo and the Politics of Lahar: Eruption and Aftermath, 1991*.

Rodolfo, K. S. and Arguden, A. T. 1991. Rain-lahar generation and sediment-delivery systems at Mayon Volcano, Philippines. *Sedimentation in volcanic settings***,** 71-87.

Rodolfo, K., Arguden, A., Solidum, R. and Umbal, J. 1989. Anatomy and behaviour of a post-eruptive rain lahar triggered by a typhoon on Mayon Volcano, Philippines. *Bulletin of Engineering Geology and the Environment,* 40**,** 55-66.

Roper, L. 2002. Achieving successful academic-practitioner research collaborations. *Development in Practice,* 12**,** 338-345.

Romieu, E., Welle, T., Schneiderbauer, S., Pelling, M. and Vinchon, C., 2010. Vulnerability assessment within climate change and natural hazard contexts: revealing gaps and synergies through coastal applications. *Sustainability Science,* 5(2), pp.159-170.

Rowling, M. 2008. NGOs: running on empty? *Tiempo 69***,** 7-11.

Ruiz, C. 2010. Chrisitan Aid good practice guide: participatory, vulnerability and capacity assessment (PVCA). Christian Aid. [Online] Available: http://www.christianaid.org.uk/Images/ Christian-Aid-good-practice-PVCA-guidelines-February-2013_tcm15-67264.pdf [Accessed: 22nd June 2014].

Sammonds, P., McGuire, B. and Edwards, S. 2010. Volcanic Hazard from Iceland: Analysis and Implications of the Eyjafjallajökull Eruption. UCL Institute for Risk and Disaster Reduction, London. [Online] Available: http://www.ucl.ac.uk/rdr/documents/docs-publications-folder/icelandreport [Accessed: 19th June 2014].

Schilling, S. P. 1998. *LAHARZ: GIS programs for automated mapping of lahar-inundation hazard zones.* United States Geological Survey (USGS). [Online] Available: http://pubs.er.usgs.gov/publication/ofr98638 [Accessed 3rd June 2014].

Schipper, L. and Pelling, M., 2006. Disaster risk, climate change and international development: Scopes for, and challenges to, integration. *Disasters,* 30(**1**), pp.19-38.

Schmidt-Thome, P. 2006. *Integration of natural hazards, risk and climate change into spatial planning practices.* PhD thesis, University of Helsinki.

Schneiderbauer, S. and Ehrlich, D. 2006. Social levels and hazard (in)dependence in determining vulnerability. *In:* Birkmann, J. (ed.) *Measuring vulnerability to natural hazards: towards disaster resilient societies.* Tokyo: United Nations University, 2006, pp. 78-102.

Schwandt, T. A. 2007. *Dictionary of Qualitative Research.* Thousand Oaks, California: SAGE.

Secor, A. J. 2010. Social survey, interviews and focus groups. *In:* Gomez, B. and Jones, J. P. (eds.) *Research methods in geography: a critical introduction.* Chichester: Wiley-Blackwell, 2010, pp. 194-205.

Shaw, R., Uy, N. and Baumwoll, J. 2008. *Indigenous knowledge for disaster risk reduction: good practices and lessons learned from experiences in the Asia-Pacific region*, Bangkok: UN/ISDR. [Online] Available: http://www.unisdr.org/files/3646_IndigenousKnowledgeDRR.pdf [Accessed: 12th June 2014].

Shepard, A., Mitchell, T., Lewis, K., Lenhardt, A., Jones, L., Scott, L. and Muir-Wood, R. 2013. The geography of poverty, disasters and climate extremes in 2030. London: Overseas

Development Institute. [Online] Available: http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8633.pdf [Accessed: 11th June 2014].

Simons, H. 2009. *Case Study Research in Practice.* London: Sage.

Smith, G. A. and Fritz, W. J. 1989. Penrose Conference report: Volcanic influences on terrestrial sedimentation. *Geology,* 17**,** 376.

Smith, K. and Petley, D. N. 2009. *Environmental hazards: assessing risk and reducing disaster*. London: Routledge.

Soanes, C. and Stevenson, A. 2009. *Concise Oxford English Dictionary.* Oxford: Oxford University Press.

Solana, M. C., Kilburn, C. R. J. and Rolandi, G. 2008. Communicating eruption and hazard forecasts on Vesuvius, Southern Italy. *Journal of Volcanology and Geothermal Research,* 172**,** 308-314.

Southgate, R. J., Roth, C., Schneider, J., Shi, P., Onishi, T., Wenger, D., Amman, W., Ogallo, L., Beddington, J. and Murray, V. 2013. *Using science for disaster risk reduction. UNISDR Scientific and Technical Advisory Group.* [Online] Available: http://www.unisdr.org/files/32609_ stagreport2013assembled.pdf [Accessed: 17th June 2014].

Sperling, F. and Szekely, F., 2005. *Disaster Risk Management in a Changing Climate*. Discussion Paper prepared for the World Conference on Distaster Reduction on behalf of the Vulnerability and Adaptation Resource Group (VARG). Reprint with Addendum on Conference outcomes. Washington, D.C. [Online] Available from: http://www.preventionweb.net/files/7788_DRMina changingclimate1.pdf [Accessed: 14th May 2014].

Stanganelli, M. 2008. A new pattern of risk management: The Hyogo Framework for Action and Italian practise. *Socio-Economic Planning Sciences,* 42**,** 92-111.

Stake, R. E. 1995. *The Art of Case Study Research.* Thousand Oaks, California: Sage.

Stake, R. E. 2000. Case Studies. *In:* Denzin, N. K. and Lincoln, Y. S. (eds.) *Handbook of Qualitative Research.* Thousand Oaks: SAGE, pp. 435-454.

Strauss, A. and Corbin, J. 1998. *Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory.* London: SAGE.

Tanner, T and Mitchell T., 2007. Embedding Climate Change Adaptation in Development Processes. *IDS in Focus,* 02, 16. [Online] Availabe from: http://www.ids.ac.uk/index. cfm?objectid=6607B374-5056-8171-7BF2651E040DB9D9 [Accessed 3rd May 2012].

Taranaki Regional Council 2014. *Volcanic hazard zones* [Online]. Available from: http://www.trc.govt.nz/volcano-hazard-zones [Accessed 26th May 2014].

Tarvainen, T., Jarva, J. and Grieving, S. 2006. *Spatial pattern of hazards and hazard interactions in Europe.* Natural and Technological Hazards and Risks Affecting the Spatial Development of European Regions. Geological Survey of Finland.

The Sphere Project, 2011. *Humanitarian Charter and Minimum Standards in Humanitarian Response.* The Sphere Handbook. [Online] Available: http://www.sphereproject.org/resources/download-publications/?search=1&keywords=&language=English&category=22 [Accessed: 30th September 2014].

Thierry, P., Stieltjes, L., Kouokam, E., Nguéya, P. and Salley, P. M. 2008. Multi-hazard risk mapping and assessment on an active volcano: The GRINP project at Mount Cameroon. *Natural Hazards,* 45**,** 429-456.

Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G. and Rockstrom, J., 2006. Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters,* 30(1), pp.39-48.

Thompson, M. 2012. Civil society and disaster. *In*: Wisner, B., Gaillard, J. and Kelman, I. (eds.) *Handbook of hazards and disaster risk reduction***.** Abingdon: Routledge, pp. 723-735.

Thywissen, K. 2006. *Components of risk: a comparative glossary.* Studies of the University: Research Counsel, Education (SOURCE) – Publication Series of UNU-EHS. No.2/2006. [Online] Available: http://www.ehs.unu.edu/file/get/8335.pdf [Accessed: 14th April 2014].

Turnbull, M., Sterrett, C. L. and Hilleboe, A. 2013. Toward Resilience: A Guide to Disaster Risk Reduction and Climate Change Adaptation. Rugby: Practical Action Publishing Ltd. [Online] Available: http://reliefweb.int/sites/reliefweb.int/files/resources/ECB-toward-resilience-Disaster-risk -reduction-Climate-Change-Adaptation-guide-english.pdf [Accessed: 10th April 2014].

Tweed, F. and Walker, G. 2011. Some lessons for resilience from the 2011 multi-disaster in Japan. *Local Environment,* 16**,** 937-942.

Tvedt, T. 1998. *Angels of Mercy or Development Diplomats: NGOs and Foreign Aid.* Oxford: James Currey Ltd. Trenton: Africa World Press, Inc.

Twigg, J. 2004. *Disaster risk reduction: mitigation and preparedness in development and emergency programming*, Humanitarian Practice Network. London: Overseas Development Institute.

Twigg, J. 2007. Disaster reduction terminology: a common-sense approach. *Humanitarian Exchange Magazine.* Issue 38 June 2007. [Online] Available: http://www.odihpn.org/humanitarian-exchange-magazine/issue-38/disaster-reduction-terminology-a-common-sense-approach [Accessed 12th June 2014].

Twigg, J. In press. Attitute before method: disability in vulnerability and capacity assessment. *Disasters,* Accepted for publication 2011.

Twigg, J. and Bottomley, H. 2011. Disaster risk reduction NGO inter-agency group learning review. London.

UK Collaborative on Development Sciences (UKCDS). 2013. *Post-Foresight agenda: Disaster Risk Reduction Research Prioritisation Exercise.* Workshop Report. [Online] Available from: http://www.ukcds.org.uk/sites/default/files/content/resources/Disasters%20004%20UKCDS_DRG_WP2%200_060613.pdf [Accessed: 11th June 2014].

Umbal, J. V. 1986. Mayon lahars during and after the 1984 eruption. *Philippine Journal of Volcanology,* 3**,** 38-59.

United Nations Environment Programme (UNEP). *Agenda 21: Environment and Development Agenda. Promoting Sustainable Human Settlement Development.* Paragraph 7.61(a). Available online: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID= 52&ArticleID=55&l=en [Accessed: 2nd April 2012].

United Nations General Assembly. *Resolution A/RES/62/192*. Resolution adopted by the General Assembly. 62/192 International Strategy for Disaster Reduction. 11th February 2008. [Online] available from: http://www.unisdr.org/files/resolutions/N0747529.pdf [Accessed 3rd May 2014].

United Nations International Strategy for Risk Reduction (UNISDR), 2004. *Living with Risk: A global review of disaster reduction initiatives.* Geneva, Switzerland. [Online] Available from: http://www.unisdr.org/we/inform/publications/657 [Accessed: 17th May 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2005. *Hyogo Framework for Action 2005-2015. In:* World Conference on Disaster Reduction, 18-22 January 2005, 2005 Kobe, Hyogo, Japan. Available from: http://www.unisdr.org/we/coordinate/hfa [Accessed: 17th May 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2006. *NGOs & Disaster Risk Reduction: A Preliminary Review of Initiatives And Progress Made.* Geneva, Switzerland. [Online] Available from: http://www.unisdr.org/2008/partner-netw/ngos/meeting1-october-2006/NGOs_and_DRR_Background_Paper.pdf [Accessed: 17th May 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2009a. *UNISDR Terminology on Disaster Risk Reduction 2009*. [Online] Available from: http://www.unisdr.org/we/inform /terminology [Accessed: 18th May 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2009b. *Global Assessment Report on Disaster Risk Reduction.* Geneva, Switzerland. [Online] Available from: http://www.preventionweb.net/english/hyogo/gar/report/index.php?id=9413&pid:34&pil:1 [Accessed: 18th May 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2009c. *Reducing Disaster Risks through Science: Issues and Actions.* The full report of the ISDR Scientific and Technical Committee 2009. Geneva, Switzerland. [Online] Available from: http://www.unisdr.org/files/ 11543_STC Reportlibrary.pdf [Accessed: 18th May 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2011. *Global Assessment Report on Disaster Risk Reduction 2011*. Geneva, Switzerland. [Online] Available from: http://www.preventionweb.net/english/hyogo/gar/2011/en/home/index.html [Accessed: 16th April 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2013. *Proposed elements for consideration in the post-2015 Framework for disaster risk reduction.* Geneva, Switzerland. [Online] Available: http://www.preventionweb.net/files/35888_srsgelements.pdf [Accessed: 17th July 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2014a. We coordinate. [Online] Available from: http://www.unisdr.org/we/coordinate [Accessed 17th June 2014].

United Nations International Strategy for Risk Reduction (UNISDR) 2014b. Co-chair's pre-zero draft of the post-2015 framework for disaster risk reduction. [Online] Available from: http://www.wcdrr.org/preparatory/post2015 [Accessed 1st September 2014].

United Nations Office for the Coordination of Human Affairs (UNOCHA), 2011. Philippines: natural hazard risks. [Online] Available: http://reliefweb.int/map/philippines/philippines-natural-hazard-risks-national-hazard-map-issued-01-march-2011 [Accessed: 8th January 2014].

United Nations Resolution A42/169/1987 Advisory Committee on the International Decade for Natural Hazard Reduction, 1987. Confronting natural disasters - an international decade for natural hazard reduction. Washington DC.

United States Geological Survey (USGS) 2012. *Magnitude 9.0 - Near the east cost of Honshu, Japan 2011 March 11 05:46:24 UTC* [Online]. Available from: http://earthquake.usgs.gov/ earthquakes/eqinthenews/2011/usc0001xgp/ [Accessed 15th June 2014].

United States Geological Survey (USGS) 2013. *Lahars and their effects* [Online]. [Accessed 17 March 2014].

University College London (UCL), 2014a. *UCL Research Ethics Committee: Accepted Ethical Standards* [Online]. Available from: http://ethics.grad.ucl.ac.uk/accepted-ethical-standards.php [Accessed 2nd June 2014].

University College London (UCL), 2014b. *UCL Research Ethics Committee: terms of reference* [Online]. Available from: http://ethics.grad.ucl.ac.uk/terms_of_ref.php [Accessed 2nd June 2014].

Usamah, M. and Haynes, K. 2012. An examination of the resettlement program at Mayon Volcano: What can we learn for sustainable volcanic risk reduction? *Bulletin of Volcanology,* 74**,** 839-859.

Valentine, G. 2005. Tell me about...: using interviews as a research methodology. *In:* Flowerdew, R. and Martin, D. (eds.) *Methods in Human Geography: a guide for students doing a research project.* Second Edition. Essex, England: Pearson Educated Limited, 2005, pp. 110-127.

Vallance, J. W. 2005. Volcanic debris flows. *In*: Jakob, M. and Hungr, O.(eds.) *Debris-flow hazards and related phenomena.* Chichester: Springer- Praxis, 2005, pp. 247-274.

Van Aalst, M. K., Cannon, T. and Burton, I. 2008. Community level adaptation to climate change: The potential role of participatory community risk assessment. *Global Environmental Change,* 18**,** 165-179.

Venton, P. and La Trobe, S. 2008. Linking climate change adaptation and disaster risk reduction. Tearfund in collaboration with the Institute of Development Studies. [Online] Available from: http://www.preventionweb.net/files/3007_CCAandDRRweb.pdf [Accessed: 23rd March 2014].

Walker, B. and Salt, D. 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World.* Washington DC: Island Press.

Walker, B. L. E., López-Carr, D., Chen, C. and Currier, K. 2014. Perceptions of environmental change in Moorea, French Polynesia: the importance of temporal, spatial, and scalar contexts. *GeoJournal*.

Wallace, T. 1997. New development agendas: Changes in UK NGO policies & procedures. *Review of African Political Economy***,** 35-55.

Walsham, G. 1993. *Interpreting information systems in organizations.* Chichester, NH: Wiley.

Wieczorek, G. F. and Glade, T. 2005. Climatic factors influencing occurrence of debris flows. *In*: Jakob, M. and Hungr, O.(eds.) *Debris-flow hazards and related phenomena.* Chichester: Springer- Praxis, 2005, pp. 325-362.

Wiggens, S. and Wiggens, M. 2009. Climate change and environmental degradation risk and adaptation assessment. First Edition. Teddington, London: Tearfund.

Williams, M. 2000. Interpretivism and generalisation. *Sociology,* 34**,** 209-224.

Wisner, B. 2006. Self-assessment of coping-capacity: Participatory, proactive and qualitative engagement of communities in their own risk management. In: Birkmann, J. (ed.). *Measuring vulnerability to natural hazards: towards disaster resilient societies.* United Nations University. Ch. 17, pp. 316-329.

Wisner, B., Blaikie, P., Cannon, T. and Davis, I. 2004. *At risk: natural hazards, people's vulnerability and disasters.* London: Routledge.

Wisner, B., Gaillard, J. and Kelman, I. 2012. Framing disaster: Theories and stories seeking to understand hazards, vulnerability and risk. *In:* Wisner, B., Gaillard, J. and Kelman, I. (eds.) *Handbook of hazards and disaster risk* reduction. Abingdon: Routledge, 2012, pp. 18-33.

Wolfe, E. W. 1992. The 1991 Eruptions of Mount Pinatubo, Philippines. *Earthquakes and Volcanoes,* 23.

Woo, G. 1999. The Mathematics of Natural Catastrophes, London, Imperial College Press.
World Bank, 2014. *Philippines* [Online]. Available from: http://data.worldbank.org/country/ Philippines [Accessed 15th June 2014].

Wynne, B. 1996. Misunderstood misunderstandings: social identities and public uptake of science. *In:* Irwin, A. and Wynne, B. (eds.) *Misunderstanding of Science? The Public Reconstruction of Science and Technology.* Cambridge: Cambridge University Press, 1996, pp. 19-46.

Yearley, S. 2005. *Making sense of science: Understanding the social study of science.* London: Sage.

Yin, R. K. 2009. *Case study research: Design and methods*. London: Sage

Yumul Jr, G. P., Cruz, N. A., Servando, N. T. and Dimalanta, C. B. 2008. The meteorologically abnormal year of 2006 and natural disasters in the Philippines. *Episodes,* 31**,** 378-383.

Yumul, G. P., Cruz, N. A., Servando, N. T. and Dimalanta, C. B. 2011. Extreme weather events and related disasters in the Philippines, 2004-08: A sign of what climate change will mean? *Disasters,* 35**,** 362-382.

Yumul Jr, G. P., Servando, N. T., Suerte, L. O., Magarzo, M. Y., Juguan, L. V. V. and Dimalanta, C. B. 2012. Tropical cyclone-southwest monsoon interaction and the 2008 floods and landslides in Panay island, central Philippines: Meteorological and geological factors. *Natural Hazards,* 62**,** 827-840.

Ziman, J. 1991. Public Understanding of Science. *Science, Technology, & Human Values,* 16**,** 99-105.